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ILLINOIS FURBEARER INVESTIGATIONS

ILLINOIS BADGER STUDIES

Federal Aid Project No. W-103-R-1-6
1 July 1989 through 30 June 1995

FINAL REPORT

by

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PROJECT INTRODUCTION

The American badger (*Taxidea taxus*), a native of the Midwest tallgrass prairie, has persisted in Illinois despite drastic reduction and alteration of its habitat. Badgers are behaviorally cryptic like many carnivores, making them a difficult species to monitor. As a result, very little is known about badgers in the midwestern United States, either prior to or since reductions in their natural habitat.

Occasional nuisance animal reports, incidental trappings, and carcasses found on roadsides have established that badgers exist in Illinois. However, details of distribution, abundance and ecology are unknown. This study was established to investigate where and how badgers survive in Illinois.

Badgers may be an important indicator of the quantity and quality of habitat suitable to prairie wildlife. Carnivores generally require larger expanses of habitat for survival than do their prey. Although very little of the original prairie remains in Illinois, some habitats are clearly supporting this species.

This report is divided into 4 chapters based on 4 aspects of the study: 1) field-based ecology study, 2) distribution, 3) abundance, and 4) literature database for badgers. Each chapter contains sections on background, methods, results and discussion of results. A final discussion of conclusions and management recommendations completes the report.

CHAPTER 1: BADGER ECOLOGY IN ILLINOIS

INTRODUCTION

The American badger (*Taxidea taxus*) is a native of the Illinois tallgrass prairie and continues to survive in the current agricultural landscape. Research in Idaho revealed that badgers avoided cultivated fields and human-induced mortality was significant (Messick and Hornocker 1981). One study of a single Minnesota badger described a home range over 5 times larger than those reported in the western U.S. (Lampe and Sovada 1981). Thus, the literature suggests that aspects of an agricultural landscape may be detrimental to badgers and may impact parameters such as home range size.

This study was initiated to provide an understanding of how badgers persist in the agricultural Illinois landscape, and what factors affect population parameters. Specific variables of interest are home range size and stability, habitat use, and demographics.

STUDY AREA AND METHODS

STUDY SITE

A west-central Illinois study site was established in Mason County, near Havana (Fig. 1). Mason County is in the Illinois River Sand Area Division of the natural divisions of Illinois

(Schwegman 1973), and is part of the Central Sand Prairie Wildlife Management Unit (WMU)(Hubert 1977, Fig. 2). Sandy soils and some rolling hills characterize the region. Sand prairie and scrub oak are the dominant native plant communities.

Row crop agriculture, often supported by irrigation, is the dominant land use in the county. Agricultural practices are less intensive than in some areas of the Grand Prairie WMU. Hedgerows, fencelines and small hay or fallow fields are scattered throughout. Initial investigations of badger sighting reports suggested that this county exhibited "higher" badger density than in other regions of the state.

The study area size was not predefined, but developed as we learned the home ranges of the badgers we were studying. It eventually covered roughly 1/3 of the county (approx. 473 km^2).

BADGER TRAPPING AND HANDLING

In 1990 we began trapping badgers, using padded #3 coil spring leghold traps set in badger den entrances. Handling and radio transmitter implantation procedures followed those used by Minta (1990). Captured badgers were restrained with noose poles and sedated with a mixture of xylazine, ketamine hydrochloride, and atropine sulfate. They were then transported to a local veterinary office where standard weight and length measurements were recorded, as well as general features of badger condition. Each badger received a uniquely numbered plastic ear tag. A blood sample, premolar tooth and fecal sample were collected. Premolar teeth were aged by cementum annuli analysis conducted by

the Wyoming Game and Fish Laboratory in Laramie, Wyoming. This lab is the only one with previous experience in ageing badger teeth.

Two-stage radio transmitters with coiled antennas were encased in electrical resin to serve as free-floating implantable transmitters (Advanced Telemetry Systems, Bethel, MN). Implantation surgery usually lasted approximately 30 minutes, during which a transmitter was placed in the peritoneal cavity of each badger. Adult transmitters operated with lithium C batteries, the entire unit measuring approximately 10.5 cm by 2.5 cm and weighing about 100 g. Juvenile transmitters were powered by lithium AA batteries, measured 9.5 cm by 1.5 cm, and weighed about 43 g. Badgers were released at the trap site as soon as they adequately recovered from sedation, usually immediately following surgery.

RADIO TELEMETRY

Results of early radio-tracking indicated the need for mobile tracking units. Two trucks were each equipped with two 4-element antennas mounted on a telescoping mast extending through the roof of the cab.

Initial efforts to radio track badgers at night while they were active resulted in inadequate data collection. Interference from topography, vegetation, other radio transmissions, and irrigation equipment was encountered. Signal strength fluctuated with badger movements, hampering signal detection and monitoring. Large badger movements and home ranges hindered our ability to

locate a badger at the beginning of a tracking session.

Consequently, we opted to locate badgers in daytime burrows. We attempted to located badgers daily, but location frequency varied with season. In summer, badgers move long distances nearly every night and signals often disappeared for days at a time. Telemetry-equipped fixed-wing aircraft were used when necessary to relocate missing badgers.

SEASON DEFINITIONS

For the purpose of various analyses we defined 3 seasons of importance to badgers. Because most of the location and movement data are from adult female badgers, season definitions are based on the female life cycle. The rearing (spring) season is from March 1 - June 30 and represents a period when movements by breeding females are somewhat restricted by parturition and rearing young. The breeding (summer) season, July 1 - October 30 includes the actual breeding period (July - August) as well as the following 2 months. This entire period is marked by frequent and large movements by females as well as males. The non-breeding (winter) season (November 1 - February 28) is a relatively sedentary period for badgers.

HOME RANGE ESTIMATION

The statistical independence of animal locations is usually a difficult issue to address, especially when locations are made several times each hour in triangulation tracking sessions. Because we used daily burrow locations, independence is easier to evaluate. Minta (1990) used a "biological time to independence"

between locations, whereby locations must be separated by an animal's shift in activity from high activity to low activity (or vice versa). Daily burrow locations by definition meet this criterion. We modified this slightly, only accepting a burrow location if we 1) knew a badger had not been in that same burrow the previous day, or 2) (in the case of a burrow being re-used) were not certain which day a badger had begun re-using the burrow, but knew it had returned to the burrow from another location.

Home ranges were estimated using the Minimum Convex Polygon method (MCP, program Home Range, Ackerman et al. 1990). Other methods were evaluated but MCP was deemed the most appropriate due to the nature of our location data. MCP is sensitive to outliers and biased with small sample sizes. It thus tends to overestimate home range size. However, because our location data are derived from actual locations (burrows), rather than triangulated estimates of locations, MCP probably underestimates badger home ranges. Badgers move great distances at night while hunting, and the area surrounding a burrow that may have been used at night is quite large. A convex polygon that connects the outermost locations in a home range does not include this movement "buffer" zone surrounding each burrow. Thus, the MCP is a conservative estimate of badger home range in Illinois. In analysis we excluded the most extreme outliers by using the 95% MCP, ignoring the outermost 5% of locations.

We plotted the number of independent locations with home

range size for 13 adult badgers to estimate the number of locations needed to reliably estimate home range size (Fig. 3). After approximately 30 independent locations, home range size did not increase markedly (although the home range sometimes slightly shifted location over time). We therefore used 30 as a minimum sample size in initial home range analyses. In addition, male #1 is excluded from some analyses. He appeared to shift from one home range to another in the course of a year (Fig. 4), which hampers estimation of his home range.

Average adult home range size was estimated in 2 ways. First, the home range was determined for each adult badger with a sample size of at least 30 locations and the mean size was calculated for each sex. Second, the home range size was estimated for each badger in <u>each year</u> for which we had at least 30 locations. This takes into account the possibility that a badger's home range may shift from one year to another. Only females had enough locations to calculate annual home ranges individually. For each, a mean was determined across years (modified average home range).

<u>HOME RANGE OVERLAP</u>

Overlap among home ranges can be difficult to estimate and interpret. However, a description of overlap can suggest behavior patterns in a species. We used a home range program (Ranges IV, Kenward, 1990) to calculate the percent overlap between individual 95% MCP home ranges that demonstrated some degree of overlap (Table 5). This method may show less

exclusivity in home ranges than actually exists because animals with adjacent home ranges that completely avoid each others' areas were not included in the analysis. Overlap is estimated only for badgers with at least 30 locations we knew could have temporally overlapped (i.e. we knew they were alive and in their estimated home ranges during the same period).

HOME RANGE STABILITY

The overlap method was also used to describe the stability of an individual's home range from one season and year to another. Dividing locations among 3 seasons or several years dramatically reduces the sample size per period. For example, we have only 6 locations for adult male #45 during the winter season, which might cause underestimation of home range size (Table 2). However, this does not present a problem because of the way we analyzed overlap among time periods.

We questioned whether an area used by a badger in one time period is contained within the area used during another period. The extreme alternative is that completely separate areas are used in different periods. We did not calculate the amount of overlap among all seasons or years for each individual badger. Doing so would describe each overlap relationship twice (e.g., spring overlapped by summer, and summer overlapped by spring). Rather, we asked how much a range was overlapped by any ranges larger than it. If, for instance, the winter home range for a badger was the smallest of its seasonal ranges, we described how much it was overlapped by spring and summer ranges. If a badger

uses the same core area during all periods and merely expands the area covered during other periods,, the smaller ranges should be completely overlapped by the larger ranges.

MOVEMENT RATE

A minimum 24-hour movement rate for badgers was calculated by determining the straight-line distance between burrows used on 2 consecutive nights. This is a minimum because occasional snow-tracking indicates that badgers travel long, circuitous paths at night.

DIGGING ACTIVITY AND HABITAT USE

After locating a badger in a burrow, field personnel measured distances to nearby landscape features that appeared on topographic maps. Burrow location was determined using Universal Transverse Mercator (UTM) coordinates from topographic maps. General habitat characteristics at burrows were recorded.

A subset of burrows were evaluated for evidence of nearby digging activity, as a measure of hunting activity. Burrows that were known to have been used $\leq$ 2 days were sampled. We established 50-m transects leading away from the burrow entrance in the 4 cardinal directions. For each transect the number and type of digs encountered and distance from the burrow were recorded.

To evaluate cover type composition within each badger's home range, we collected information on planting in individual fields from the local Agricultural Stabilization and Conservation Service (ASCS) office in 1992, 1993, and 1994. Because overall

cover composition changed little among years, we used only the 1993 data set to record cover types of most fields on aerial photos of the study area. Linear cover types such as roadsides, fencelines, and hedgerows were mapped in the field on topographic maps, from which UTM coordinates were derived. All of these data were digitized and summarized in a Geographic Information System (GIS) using a SUN SPARC station IPX with ARC/INFO version 6.1.1 software.

Burrow cover type analysis was performed by comparing the cover types used for burrows with 2 separate data sets. First, we estimated cover types available to badgers from agricultural statistics for Mason County (Census Bureau, 1993). Second, for a subset of badgers we calculated available cover for each individual's home range from the GIS cover map generated from ASCS data.

In addition, we wanted to determine the relationship between badger burrow location and linear cover types (fenceline, hedgerow, field border, roadside, ditch banks). It is a widely-held but virtually untested belief that carnivores use these cover types, often called "corridors", as travel lanes. Badgers may use corridors for travel and/or hunting. We generated random points within each badger's home range, and calculated the average distance from these points to the nearest corridor using ARC/INFO software. Then the average minimum distance to corridors was calculated for all burrow locations for each badger.

POTENTIAL PREY AVAILABILITY

To estimate badger prey availability on the study site, small mammals were captured with Sherman live traps during 1991 and 1992. We trapped in 6- or 7-station by 6- or 7-station grids, with 10 m between each station. One trap was set at each station and was baited with peanut butter and rolled oats. We trapped in 6 cover types in both spring and summer.

In Illinois, the most significant variable that might affect badger prey availability among cover types is the frequency and type of soil disturbance caused by agricultural activities. Fields that are plowed, planted, and harvested regularly have little or no permanent vegetative cover, offering limited habitat for burrowing small mammals (pers. obs.).

Therefore, for this analysis we assigned cover types to 1 of 2 simple cover categories: "disturbed" and "undisturbed". Disturbed sites are fields where corn, soybeans, and small grains are planted. Relatively undisturbed sites include linear habitats such as hedgerows and roadsides. Also in the undisturbed category are alfalfa fields and fields enrolled in the federal Conservation Reserve Program (CRP).

BADGER CARCASS COLLECTION

Badger carcasses were collected statewide during the project. Roadkills and incidental captures by trappers were the most common sources. Simple necropsies were performed on the carcasses to determine age, sex, cause of death, and stomach contents.

POPULATION MODEL

We used a simple population model to evaluate different possible scenarios for Illinois badgers. This model is loosely based on a model developed for reintroduced river otters in Missouri (David A. Hamilton, pers. comm.). A desktop calculated was used to generate the outputs of this simple model.

STATISTICS AND ANALYTICAL APPROACH

For summary and analysis of all data collected from radio-transmittered badgers, the sampling unit was defined as an individual badger. This takes into consideration individual variation in all parameters, including movement rate, digging behavior, choice of cover type, and reproduction. For instance, the frequency distribution of cover types chosen for burrows was determined for each badger and then averaged for various classes of comparison, such as adult males and females. In many cases we only analyzed data for adults. We were able to monitor only a few juveniles post-dispersal, and their movements were variable and erratic.

For statistical comparisons, if the data appeared normally distributed we used parametric tests. If data were non-normal we used non-parametric tests.

Further details of some analytical methods are included in the results section. The somewhat complicated approaches should be clearer when explained in direct reference to results.

RESULTS

BADGER TRAPPING

Between 1990 and 1994 we captured 42 badgers (23 juveniles and 19 adults, Table 3). Two badgers are known to have died from handling. An adult male died at the clinic from pulmonary artery laceration during a heart puncture procedure for blood sample collection. A juvenile male died one week after release due to an infection at the surgical incision site. All other badgers quickly recovered from surgery. Females conceived and bore young while outfitted with transmitters. Four badgers sustained minor limb injuries from the trapping experience (torn claw, puncture wounds from biting at trap). These injuries were treated and badgers recovered. An adult male had previously lost 3 toes, possibly in an incidental trapping event. An adult female had a previously broken forelimb that had also healed at the time we captured her. Two females were recaptured and their transmitters replaced when batteries appeared to be failing, but recapture attempts on other badgers were unsuccessful.

HOME RANGE SIZE

The number of independent locations per badger ranged from 3 to 282 (Table 4). The duration of the study and the transmitters allowed for long term monitoring of some badgers. One adult female was tracked for almost 4 years and 3 individuals were tracked for about 3 years.

Home range estimates for badgers were based on a minimum of 5 independent locations (Table 3). The modified average home range for adult females (13.05 km^2) is significantly smaller than the average home range of adult males (44.11 km^2, Kruskal-Wallis test, P=0.008). Females' average home range size (unmodified, 19.59 km^2) is larger than the modified home range size, but is still significantly smaller than the average male home range (Kruskal-Wallis test, P=0.038).

HOME RANGE OVERLAP

Adult females experienced more overlap by adult males than by adult females, as expected in a polygynous mating system (Table 6). Home ranges among females were fairly exclusive, as were home ranges among males. Juveniles experienced more overlap by adult males than adult females.

HOME RANGE STABILITY

Seasonal home range sample sizes and estimates varied greatly among badgers (Table 2). A seasonal overlap mean was calculated for each individual, indicating relative home range stability from one season to another (Table 7). The mean seasonal overlap is significantly higher in adult females (92.27%) than in males (55.61%, Kruskal-Wallis test, P=0.007). This suggests that adult females have more seasonally stable home ranges than do adult males.

Annual home ranges and estimated overlap for individuals are described in Tables 8 and 9, respectively. Female ranges are more stable annually (85.06% annual overlap) than are males'

(56.38% annual overlap, Kruskal-Wallis test, P=0.039). These data support our field observations that some males moved to completely new areas, making radio-tracking them difficult. The disappearances of some males (Table 3) might be attributed to movements out of the study area.

MOVEMENTS

The sample size of minimum distance moved ranged from 0 to 88 per badger (Table 4). As expected because of home range size differences, adult male movements are greater on average than those of adult females (Fig. 5), although this difference is only significant during the spring period (Kruskal-Wallis test, P=0.025). A larger sample for males in summer and possibly in winter might reveal further significant differences.

DEMOGRAPHICS

We collected 123 badger carcasses from throughout Illinois during the study. Data from an additional 14 carcasses collected and examined prior to the project by Department of Natural Resources personnel (Tom Beissel and Jeff Ver Steeg, unpublished data) are included in the summary (Table 10). The majority of these carcasses were roadkilled badgers (85%), collected year round. These data do not reflect a seasonal pattern in the frequency of roadkills.

The age distributions of all carcasses and study site animals (age at capture) do not appear to be different (Fig. 6). Most badgers examined were 3 years old or younger. The study site sample is biased towards juveniles, since each year we

captured the juveniles produced by adult females in the study. The sample of collected carcasses may also be biased towards juveniles since most of the carcasses are roadkills and dispersing juveniles might be especially vulnerable to vehicle collisions. The sex ratio in both collected carcasses and study animals appears to be nearly 1:1 (Fig. 7).

The mean proportion of females producing young each year averaged 0.71, mean litter size was 1.69, and the mean proportion of juveniles known to have survived to disperse was 0.21 (Fig. 8). Females were deemed to have produced young if we saw evidence of active young at burrow sites. We could not detect instances in which all members of a litter died before being able to move around outside the burrow. Mean litter size was determined by the number of young we captured and/or observed at burrows. Proportion of juveniles surviving to disperse was calculated using the juveniles that we tracked after dispersal and those we knew had died prior to dispersal. Several juveniles' transmitter signals disappeared in late summer and we were unable to determine if they had dispersed or died (Table 3). Data from these animals were eliminated from calculations for proportion of juveniles surviving to disperse.

Reproductive information from female carcasses was limited because of their often poor condition. Of 33 adult females with known reproductive status, 61% were known to have bred at least once, and 29% had not bred (Table 11). Of the 22 females of known age (all adults) and reproductive status, 36%, aged 1 - 3,

had not bred. This sample may be biased if the nightly movements of lactating females make them more vulnerable to vehicle collisions.

POTENTIAL PREY AVAILABILITY

Small mammal density was calculated for each trapping site in each season and year. Density was defined as the number of mice captured (recaptures not included) divided by the area covered by the trapping grid. Results were not different among seasons or years, so data were pooled for each of 5 cover types (Table 12).

Average small mammal density was significantly higher in the undisturbed than in the disturbed cover category (t-test, P=0.025, Fig. 9). Furthermore, the number of prey species found at undisturbed sites was higher than at disturbed sites (Fig. 10). Two of the species found only in undisturbed sites, *Microtus ochrogaster* and *Spermophilus tridecemlineatus*, have a higher mean individual body weight than the 3 species found in disturbed sites (Fig. 11, Schwartz and Schwartz 1981). Not only is there a greater density of potential prey at undisturbed sites, but the individual prey items have higher biomass.

DIGGING ACTIVITY

Digging activity was recorded at 133 burrow sites used by 17 badgers. Because data suggested there could be differences in digging activity between adults and juveniles, we present data only for adults. The mean distance of digs from the burrow at each site was calculated, and then a mean was calculated for each

badger for all of its burrow sites. The average distance of digs from a burrow entrance was 17.4 m (N=10 adult badgers).

HABITAT USE

Cover type at each of 814 separate burrows was recorded. For analysis of burrow cover type preference, we only included badgers with at least 15 burrow locations.

According to the digging activity data, badgers often dig daytime burrows at or near a feeding site from the previous night. Thus, prey availability in the various cover types may influence burrow cover choice. For habitat use data we used the same 2 cover categories, disturbed and undisturbed, that we defined for the prey availability analysis. In addition to the previously listed cover types, the undisturbed category for burrow use also included fencelines, undisturbed field borders, ditch banks, hayfields, fallow fields, woodlots, and non-agricultural cover such as grass lawns and grass airstrips.

For 12 adult badgers, number and frequency of burrows in the 2 cover categories are reported in Table 13. Frequencies did not differ between females and males, so data were pooled for all adults. Agricultural statistics used to describe land use summarize data for all land not in use for towns, farm buildings, ponds and roads. According to these data, over 2/3 of the agricultural land in Mason County can be classified in the disturbed category. Badgers only used disturbed cover for about 1/3 of their burrows (Fig. 12). Alternatively, badgers used undisturbed habitats for burrows about 2/3 of the time, though

these cover types comprise less than 1/3 of the agricultural lands. Without performing extensive preference analyses, it is clear that badgers are using undisturbed cover types for burrows disproportionately to availability.

To compare burrow cover use to available cover in each badger's home range we used a reduced sample of 10 adult badgers. Available home range cover types data were incomplete for the other 2 adult badgers. We again categorized cover types according to the disturbed/undisturbed scheme. For each home range we determined the percentage of known cover type in these 2 categories (Table 14). The number of burrows expected to be in each cover type was calculated by multiplying the total number of burrows by the percentage of cover available (Table 14). The number of burrows in disturbed cover types was lower than expected by cover availability (Kruskal-Wallis test, P=0.015), and the number of burrows in disturbed cover types was higher than expected (Kruskal-Wallis test, P=0.008). Burrows were also significantly closer to corridors than were random locations (Table 15, t-test, P=0.008).

FOOD HABITS

Stomach contents of 19 badger carcasses were identified to the most specific level possible. The percent of samples containing evidence of several prey categories was calculated (Table 16). The majority of samples contained evidence of mammalian prey (0.89) and a surprisingly large proportion contained evidence of snakes and/or toads (0.21).

We used these data to examine badger hunting habitat use by grouping prey species into 2 categories and recalculating percent occurrence. Prey availability results suggest that some small mammal species are associated primarily with the undisturbed cover category (Fig. 10). These include all prey items identified except "small rodents" and insects. The small rodents designation indicates evidence of small mammals that could not be identified at the species level, although we were certain that these small mammals were not *Microtus sp.* or *Spermophilus sp.* Although this category might include some species that would occur primarily in undisturbed cover types, such as *Blarina brevicauda*, *Peromyscus leucopus*, and *Reithrodontomys megalotis*, to be conservative we assumed all items in this general category would be found primarily in disturbed cover types. Almost 3/4 of the stomachs examined contained at least one item from undisturbed cover types (Table 16).

POPULATION MODEL

We estimated several demographic parameters from badgers in the telemetry study for use in the population model. Annual survival rates were 0.45 for adult males and 0.87 for adult females, with a combined adult mortality rate of 0.71 (derived from Table 3). Combining the proportion of adult females producing young each year, mean litter size, and proportion of juveniles surviving to dispersal (Fig. 8), we derived an estimate of reproductive output. This is defined as the number of young expected to survive to dispersal, per adult female, each year.

Annual reproductive output was 0.35.

To keep the model simple, and to avoid arbitrarily assigning parameter estimates, we made several assumptions. All of these assumptions, if incorrect, will tend to overestimate population growth. We assumed that juvenile survival post-dispersal was 100%, which is probably not realistic. However, we have no information on juvenile survival for more than a few months post-dispersal. We also assumed adult survival was constant, although it is quite possible that yearlings experience higher mortality than older adults. The only yearling badger trapped and tracked survived $\leq$ 2 years. We assumed that all adult females bred annually, which is not always the case.

We have no information on breeding in juvenile female badgers. The literature reports the proportion of breeding juvenile females ranging from 0 (Minta 1990, Lindzey 1971) to 0.52 (Messick 1987). In our model we used 2 scenarios, 1 with all juvenile females breeding, and 1 with no juvenile females breeding.

Emigration and immigration were disallowed in the modelled population. The initial population in the model had a sex ratio of 1:1 and juveniles were produced in a 1:1 ratio (see Figs. 6 and 7). We did not include any stochasticity in the model.

The model started with 100 badgers, 50 adult males and 50 adult females. We ran the model for 20 years under 3 scenarios: 1) adult male and female survival was equal and all juvenile females bred, 2) adult male and female survival was different and

all juvenile females bred, and 3) adult male and female survival was different and no juvenile females bred. Under scenario 1 the population declines to near 0, in scenario 2 the population increases exponentially, and in scenario 3 the population increases slowly (Fig. 13). Because the first scenario is least plausible, i.e. we believe male and female survival rates are different, we continued analysis using only differential adult survival. Examination of the population sex ratios under scenarios 2 and 3 shows the proportion of males and females in the population diverges widely early in the model, and remains so (Figs. 14 and 15).

The effect of a limited trapping season for badgers on the population was then added to the model. If a season were opened, it is impossible to predict what sort of pressure trappers would exert on the badger population. Badger pelts currently have little economic value. However, re-opening the trapping season since its closure in 1957 may initially generate unusual interest in taking a badger as a "trophy" or novelty.

We relied on the Missouri river otter model for a trapping rate (David A. Hamilton, pers. comm.). Data collected from 806 otters released since 1983 indicate an incidental trapping rate of 0.045. Otters would be incidentally caught in different types of sets than would badgers. However, if a season were opened for badgers in Illinois, they would ultimately be trapped primarily incidentally to trapping for other species. An incidental trapping rate can be difficult to estimate except when a species

that is reintroduced and closely monitored, as in the Missouri example. Thus, we used this rate in our population model, assessing an additional 0.045 annual mortality rate due to trapping on adult males and females. We assumed juvenile trapping mortality to be 0, which is not realistic, but keeps the model simple. In the model population with juvenile females reproducing, the additional mortality associated with trapping markedly reduces the population growth rate, although the population continues to grow (Fig. 16). In the scenario with no juvenile females reproducing, the population slowly declines (Fig. 17).

DISCUSSION

Results from the field study indicate that relative to other population studied in the western U.S., badgers in Illinois have unusually large home ranges. Previous studies in Idaho, Utah and Wyoming have reported mean 95% MCP home range sizes ranging from 2.4 - 7.99 km^2 for adult males and from 1.6 - 2.71 km^2 for adult females (see summary in Minta 1990). One adult female tracked in Minnesota for 6 months used a 17 km^2 area (Lampe and Sovada 1981). A second Minnesota adult female's home range was 8.5 km^2 during a 5-month period. The mean home range sizes in Illinois (adult males, 44.91 km^2; adult females, 19.59 km^2, Table 4) are most similar to the first Minnesota example.

Minta (1990) hypothesized that the Minnesota badgers' large

home ranges could be a result of lower prey biomass per unit area. Badgers in Minnesota fed primarily on pocket gophers (*Geomys bursarius*), which we found at our study site.

Small mammal trapping results suggest that the majority of Mason County's corn- and soybean-dominated landscape offers low densities of small rodents as potential badger prey, relative to undisturbed cover types (Figs. 9 and 11). The larger prey species such as *Microtus ochrogaster* and *Spermophilus tridecemlineatus* are more densely distributed, but only in small fragmented patches of relatively undisturbed habitat, such as alfalfa, hay and CRP fields, and linear habitats (Figs. 9 and 11).

Our small mammal trapping regime did not sample for pocket gophers. However, the species does exist at the study site in Mason County and we can report anecdotally that evidence of their presence seemed most common in undisturbed cover types, especially alfalfa, hay and CRP fields. Pocket gophers in Minnesota represent a meager prey base as compared to ground squirrel and prairie dog colonies in Wyoming (Minta 1990). In Illinois they would represent one of the better prey sources for badgers, based on their large mass (141 - 510 g, Schwartz and Schwartz 1981). However, pocket gopher population density and distribution among cover types should be examined to better described availability of this species as badger prey.

Of the 19 badgers used for stomach content analysis, 18 were recovered from known locations. Nine of these came from counties

within the distribution of pocket gophers, but only 1 displayed evidence of pocket gophers being predated by badgers (Table 16). Because this sample size is small, it is difficult to draw conclusions regarding badger predation on pocket gophers.

Badger stomach contents analyzed also suggest that badgers hunt more often or more successfully in undisturbed cover types (Table 16). This sample is biased in that most carcasses were roadkilled animals, and by definition were in or near an undisturbed cover type (roadside). However, given the distance that badgers can travel at night (Fig. 5) and the frequency with which they might encounter the dominant disturbed cover types (Fig. 12), even badgers killed on roads have had ample opportunity to concentrate hunting activity in row crop fields.

Burrow use data indicate that badgers prefer to use undisturbed covers for daytime dens (Fig. 12). This is most likely due to the greater availability of food sources, but may also be linked directly to badger survival. We recorded 4 separate events of agricultural equipment causing the deaths of badgers while they were in daytime burrows (Table 1, badgers 9, 10, 11, 22, 37 and 42). In 2 of these cases, adult females and their offspring perished. One of these ill-fated burrows was on a roadside, which we considered as relatively undisturbed by agricultural activities. However, the "disturbed/undisturbed" categories were developed primarily with reference to activities that might affect small mammal density. That is, repeated plowing and planting will change the small mammal species

composition and reduce overall small mammal density more dramatically than will regular mowing. However, mowing may also be detrimental to individual badgers. Safest cover types with regard to this aspect of badger survival are those that experience little or no agricultural activity. In summary, lack of regular plowing and planting contributes to a healthy potential badger prey base. Lower frequency of other human activity, such as mowing, would reduce the potential for badger fatalities.

Analysis of burrow placement shows that burrows are usually located closer to corridors (linear, relatively undisturbed cover types) than expected by chance. This suggests that badgers use corridors as travel lanes, and possibly for hunting. However, in regards to badger safety, corridors may pose additional risks, especially to juvenile badgers. Young badgers in corridors such as hedgerows may more frequently encounter other predators, such as coyotes and dogs, that may travel along corridors. In all 5 incidents in which juvenile badgers were known or believed to have been killed by canids, the badgers were recovered and/or were known to have a burrow within 25 m of a corridor. Although adult badgers are less vulnerable to predation by canids, at least 1 adult male badger (unmarked) in our study area was killed by dogs; other similar incidents were reported statewide during the study.

The large home range size exhibited by Illinois badgers poses other questions. Since these are the largest home ranges

reported in the literature, are badgers able to maintain these ranges exclusive of other badgers for long periods of time? Is the social system altered by the low population density? Does this home range size represent the limits of how far badgers can range and still survive? Results from the overlap analyses answer some of these questions.

Home ranges are remarkably stable from year to year and season to season, especially in adult females (Tables 9 and 12). Intrasexual home range overlap is low (< 30%, Table 6), suggesting badgers are able to maintain reasonably exclusive territories, despite the large size. Because badgers most likely use the long-lasting communication system of scent to mark boundaries of use and are superb at detecting scent (Messick 1987), this is not surprising. Nevertheless, it would still seem possible for interlopers to invade other badgers' home ranges quickly and intermittently without encountering residents due to the large range size. It is possible that this occurs and we were unable to detect it. However, it is not likely a common strategy.

As expected in a typical mammalian polygynous system, male home ranges are primarily intrasexually exclusive, but are larger than (Table 5) and overlap those of females (Table 6). If limited food and/or safe burrow habitat drives the females to cover large areas, one might expect that at some limit it will be energetically difficult for males to overlap the ranges of more than one female. This does not appear to the case.

However, we have some evidence that the scale of badger movements in Illinois negatively affects adult males. Females exhibit more stable home ranges than males, both seasonally and annually. We noted 2 cases in which adult males (ages 2 and 3) abandoned one area for another. The locations of 1 of these males are in Fig. 4. We recorded only 3 locations for the second male (#17), but he apparently moved at least 19.4 km between locations and subsequently died. In 1 other case, we suspect another male (#20) made a long distance permanent move because we lost radio contact. It is possible that our relatively small samples did not allow us to detect similar long distance movements and/or signal loss in adult females. However, it is significant that we did not see a single instance of either of these phenomena for females, despite the fact that we trapped and tracked similar numbers of males and females, of similar ages (Fig. 6).

Mortality rates also appear to be higher for adult males than females. Because males have larger home ranges, they probably cross more roads and cover unfamiliar territory more frequently than females. Numbers of encounters with motor vehicles, agricultural equipment, other badgers, coyotes, and dogs might all increase as a result, possibly affecting mortality. Males that make long distance permanent moves would be especially vulnerable in this regard.

In any population model output is affected by model assumptions and reliability of the specified parameter estimates.

Our results suggest that at least one of our parameter estimates is not realistic. The sex ratios in the resulting populations differ greatly from 1:1 (Figs. 14 and 15), but we found sex ratios of essentially 1:1, both in our study population and in the collected carcass sample (Fig. 7). The model's unrealistic sex ratio results from the low male survival rate of 0.45. Clearly, the population is more complicated than our model allows for. Although the male survival rate is the actual rate recorded from field animals, it is based on a small sample (N=10). We believe that males do experience higher mortality than females, but we may have overestimated the difference. It is possible that males experience higher mortality than females only in early adulthood. In any case, we choose to use the model and interpret results using our original parameter estimates rather than arbitrarily altering male survival rates.

In both cases tested, the additive trapping rate of 0.045 had a major impact on the population (Figs. 16 and 17). It is not known whether or not trapping mortality would be additive. Badgers are now incidentally trapped in Illinois, although this is not regularly reported to Illinois Department of Natural Resources (IDNR) personnel. Our survival rates are based on the badgers with known fates. That is, if a badger's radio signal disappeared, we excluded it from further survival analysis. Signal disappearance could result from emmigration or destruction (including by incidental trapping) of the badger and transmitter. None of the study badgers that died are known to have perished

due to trapping. Thus, although incidental trapping occurs in Illinois badgers, it was not included in the mortality estimates derived from the study population for the model.

Would a trapping season add to the mortality rates of badgers? Perhaps, since incidental trapping already occurs, it would not, at least on a statewide level. In any case, it is legitimate to consider trapping as additive in the model since the model does not already include incidental trapping deaths.

CHAPTER 2: BADGER DISTRIBUTION IN ILLINOIS

INTRODUCTION

Most historical references to badgers in Illinois have been anecdotal (Kennicott 1855, Thomas 1861, Wood 1910, Cory 1912, Sanborn 1930, Gregory 1936, Koestner 1941, Necker 1941, Mohr 1943, Anderson 1951). Since badgers are associated with open, grassland-like habitats, their range was considered restricted to the prairie region of Illinois (northern two-thirds) prior to settlement by Europeans. A recent report indicates badgers have expanded their distribution to some counties in the southern third of the state (Gremillion-Smith 1985). A systematic examination of badger distribution has been lacking and was one goal of this study.

METHODS

BADGER SIGHTING DATABASE

Because badgers appeared to be uncommon in Illinois, we attempted to collected distribution data through a variety of methods.

Several current IDNR sources of Illinois badger sightings were surveyed in an effort to collect all reports since about 1979, 10 years prior to the initiation of this study. These sources included: 1) records of Division of Wildlife Resources

(DWR) personnel Tom Beissel and Jeff Ver Steeg, who collected badger sightings from approximately 1981-1989, 2) periodic reports on badger distribution by George Hubert (DWR), and 3) updates from the Natural Heritage Database, Division of Natural Heritage.

DWR personnel were contacted to inform them of our quest for badger sightings. A report form was designed and distributed (Fig. 18). In addition, Division personnel contacted us when applications for nuisance animal or salvage permits were submitted with specific mention of badgers. A badger mount and poster were displayed in Conservation World at the State Fair for several years.

To solicit badger sightings during the course of the study we designed and printed an informational poster that contained postcards for observers to return with sighting information (Fig. 19). The design was a modified copy of a poster used by John Messick (pers. comm.) in Missouri. Badger illustrations were obtained by permission from Scwhartz and Schwartz (1981). We distributed posters to DWR offices, county ASCS offices, county forest preserve districts, and other locations where people who spend time outdoors might see them. We particularly tried to cover counties where sightings had not yet been recorded.

Since roadkilled badgers represented a large number of the reports already on record, we contacted Illinois Department of Transportation (IDOT) personnel for reports. A memo and copy of the informational poster were distributed to IDOT field

personnel. Illinois Natural History Survey (INHS) personnel were also informed of the need for badger distribution data.

Occasional articles about the project were published in conservation and nature publications, as well as local newspapers. Readers were asked to report badger sightings to INHS personnel. Project personnel also presented several talks to local groups about the project. Some badger sightings resulted from these contacts.

Badger sightings from previously unrecorded counties were confirmed by direct phone contact with the observers. Several badger features and behaviors were considered diagnostic and could confirm an authentic badger sighting. Observers were encouraged to describe the badger sightings in their own words as project personnel listened for the diagnostic features.

Sighting reports from previously recorded counties were also scrutinized for diagnostic features, although not all observers were contacted by phone. We relied on IDNR employees to evaluate reliability of observers from whom they collected reports.

Evidence of breeding badgers was gleaned from badger sighting records wherever possible. We confirmed breeding if a lactating female was reported (evidence often from recovered carcasses), or if juveniles were reported from spring through August, the period during which juveniles are easily distinguishable from adults.

DISTRIBUTION DATA FROM RELATED SURVEYS

Data from 2 furtrapper surveys (see Chapter 3) were reviewed

for additional badger distribution information. As part of a separate project (Federal Aid Project No. W-111-R-1,2,3,4), an archery deer hunter survey (ADHS) designed for red fox sightings also proved useful. This survey has space for sightings of other furbearers, including badgers (Warner and Ver Steeg 1994). Badger reports from these surveys were not confirmed by contacting observers.

RESULTS

Of the confirmed badger sighting reports, the majority were referred by IDNR (excluding INHS) sources (47%, Fig. 20). However, all sources provided reports in previously unrecorded counties and/or allowed collection of badger carcasses. The number of annual badger sightings peaked during the six years of the study (Fig. 21).

Badgers are distributed throughout Illinois (Fig. 22). Four counties exhibited no confirmed badger sighting reports. For 2 of these, Saline and Wabash, we did receive unconfirmed badger sightings in the 1993 ADHS. Reports from the furtrapper surveys did not add any new counties.

Badgers also appear to breed throughout Illinois (Fig. 23). Although breeding badgers have not been documented in every county, evidence of breeding badger was obtained from all WMU's except the Wabash Border WMU.

DISCUSSION

Badgers are distributed well beyond the former boundaries of the tallgrass prairie in Illinois (Fig. 22). Previous research documented badger presence in some southern Illinois counties (Gremillion-Smith 1985, Klimstra and Roseberry 1969), but the extent of the species range was unknown. Gremillion-Smith (1985) hypothesized that alteration of the landscape in southern Illinois had proved beneficial to badgers, allowing them to expand their distribution. Agriculture and strip-mining practices resulted in cleared forests, more open fields, and more abundant rodents. We concur that these factors have most likely permitted badgers to expand their distribution to encompass the entire state.

Sometimes a species is widely distributed, but is self-sustaining in only a few "source" populations. Although breeding badger records are not as widespread in the southern portion of Illinois as in other areas, reproduction does not appear to be limited to isolated core populations.

CHAPTER 3: BADGER ABUNDANCE IN ILLINOIS

INTRODUCTION

Animal abundance is a parameter of great interest to managers, researchers, and the public. It is also one of the most difficult to estimate reliably. For species such as the badger, which in Illinois is wide-ranging (see Chapter 1), solitary most of the year, and primarily nocturnal, monitoring of abundance is especially problematic.

Historical information on badger abundance is virtually non-existent. Most historical furbearer information comes from trapping records, which have a strong bias associated with pelt price (Obbard et al. 1987). Furthermore, because badger furs have never had high economic value, these data are limited.

Recognizing these difficulties, we explored several techniques for indirectly assessing badger abundance and estimating regional differences in population numbers.

METHODS

BADGER SIGHTING DATABASE

To examine badger abundance we relied on several techniques. The database containing badger sighting records collected during the project (see Chapter 2) can be used to examine relative badger abundance. The number of sightings per county may be

influenced by the number of effective observers and their level of interest in badgers. However, it is possible that frequency of sightings is correlated with badger density at the county level. We categorized counties according to the number of badger sightings. Most counties had less than 15 sightings while a few potentially important counties had 15 or more sightings (Fig. 24).

FURTRAPPER SURVEYS

We mailed a contact letter and questionnaire to a random sample of 2400 trappers in November, 1989 to inquire about incidental badger catches (Fig. 25). A reminder letter was sent 2 months later. Instead of conducting a second complete survey in 1993 as scheduled, we added one question to an ongoing IDNR survey of 850 trappers (Fig. 26, Anderson 1995). Data from both surveys were summarized by county.

ARCHERY DEER HUNTER SURVEY (ADHS)

Two techniques from a separate project on red foxes (Federal Aid Project # W-111-R 1,2,3,4) augmented badger abundance information. The ADHS generates an index of number of badgers seen per 1000 hours of archery deer hunting (Warner and Ver Steeg 1994). This index was too variable to be reliable for the seldom-reported badger, so we only used sightings only for county presence/absence data.

AERIAL SURVEYS

Spring aerial surveys for fox dens also have the potential to reveal important badger density information. We conducted

slow, low altitude flights over 1 township in each of 6 Illinois counties, recording active fox dens and other digging activity (Warner and Ver Steeg 1994). In 1994 we made an exception to this procedure because inclement weather allowed us to survey only 12 sections, rather than the standard 36, in Mason County. We report data from these surveys in 1993 and 1994, and consider the technique's potential in evaluating badger abundance.

BADGER HOME RANGE EXTRAPOLATION

We also generated a limited badger abundance estimate by extrapolating density information from adult badger home range data collected at our field site in Mason County. We used average adult male and female home ranges and estimates of intrasexual home range overlap to determine the average area of exclusive use for adult badgers of each sex. For adult females we used the modified 95% home range rather than the simple 95% home range because it accounts for annual shifts in home range (see Chapter 1). This approach may overestimate adult female badger density.

For this analysis we ignored estimates of male/female home range overlap and simply overlaid male and female density estimates, summing them for overall badger density. Because badgers display a typical polygynous mating system, male home ranges are expected to overlap female home ranges. It is theoretically possible for all of a female's home range to be encompassed by a male's territory, and for a male's territory to be completely overlapped by the combined ranges of several

females. Although our evidence does not indicate 100% intersexual home range overlap (Table 1), the analysis is much simpler when 100% overlap is assumed. We recognize this method could lead to an overestimate of badger density.

RESULTS

BADGER SIGHTING DATABASE

Nine counties had 15 or more badger sightings recorded during the study (Fig. 27). These counties are located in 2 clusters in central Illinois, and 1 county is in northwestern Illinois.

FURTRAPPER SURVEYS

Approximately 51% (1234) of trappers surveyed responded to the 1989 trapper survey. At least one trapper in each county responded. Trappers reported incidentally trapping badgers from 1986-1989 in 34 Illinois counties (Fig 28). The 577 trappers (68%) who responded to the 1993 survey (from 89 counties) only reported trapping badgers in 19 counties for the years 1990-1993 (Fig. 29, Anderson 1995). A map consolidating results from both surveys indicates that in some counties, especially in the northwest part of the state, badgers were consistently reported (Fig. 30).

ARCHERY DEER HUNTER SURVEY

Distribution of badger sightings from each of 4 years appears random (Figs. 31 - 34). Combining data from all 4 years

fails to reveal a pattern in sighting distribution (Fig. 35). We also combined results from the trapping surveys with the ADHS information (Fig. 34). We grouped counties that had incidental badger trappings in both surveys (from Fig. 30) with counties that showed badger sightings in at least 2 years of the ADHS (from Fig. 35). Seven counties demonstrated consistently large numbers of badger encounters in the 2 survey types (Fig. 36). Five of these counties are in northwestern Illinois.

AERIAL SURVEYS

Aerial survey results indicated that total number of digging sites per section varied greatly among counties in both 1993 and 1994 (Fig. 37). Because of inclement weather, we were unable to sample all 6 counties in either year. For the same reason the 1994 flight in Mason County covered only 12 sections, rather than the standard 36. The highest densities of digs were in Logan County, 1993, and Carroll County, 1994. Mason County showed moderately high dig density, and Ford County showed low dig density in both years.

HOME RANGE EXTRAPOLATION

As expected from home range analysis, adult female badger density is estimated as more than twice that of adult males (Table 17). The estimated overall badger density in Mason County is 0.14 badgers/km^2, or 1 badger per 7.14 km^2 (2.72 mi^2).

DISCUSSION

All approaches we used to examine badger abundance are indirect and have biases or other potential disadvantages. Drawing conclusions from the badger sighting database is risky because observer effort, ability and density are not uniform across the state. Results from this database suggest that badger sightings, and by inference, badgers, are most common in central Illinois (Fig. 27). However, the 2 clusters of counties in the middle of the state are centered near Sangamon and Champaign counties, in which project personnel reside. Furthermore, DWR and INHS central offices are in these 2 counties, respectively. We suspect these data do not offer an unbiased estimate of badger abundance.

The low percentage of furtrapper survey responses in 1989 may have resulted in a biased respondent sample. The 1993 survey had a better response rate, but not all counties were sampled. Examining these samples separately, it is difficult to distinguish a pattern of incidental captures, but the combined sample suggests the northwestern portion of Illinois may support more badgers than elsewhere (Fig. 30). This observation concurs with our general impression that this is one area of the state with relatively high badger numbers. Because of the potential biases associated with the furtrapper surveys, however, it is best to compare results to those from other methods.

The ADHS also reveals no obvious pattern of badger sightings in individual years, nor does the combined 4-year sample allow simple conclusions (Figs. 31-35). Observers in this survey, archery deer hunters, are generally avid outdoors enthusiasts with good observational skills. In some years there were over 2,000 participants distributed throughout all counties (Warner and Ver Steeg 1993). However, observer density was not uniform throughout the state. Results only indicate whether or not badgers were sighted in a county, not how frequent sightings were. The wide distribution of counties with sightings over 4 years suggests that badgers are widespread and sporadically observed by survey participants. This fits the profile of Illinois badgers that emerged from Chapters 1 and 2. When comparing the trapping survey and ADHS data, several counties in northwestern Illinois again stand out, due mostly to the influence of the trapping survey data (Fig. 36).

The limited results of the aerial surveys are difficult to interpret because they are not consistently repeated between years (Fig. 37). Ford County stands out as having low badger activity in the 2 years flown. Given the apparent importance of undisturbed cover types such as hayfields, fencelines, and hedgerows to badgers (see Chapter 1), it is intuitive that badgers are uncommon in the intensively farmed Ford County landscape.

Because badger population density is difficult to estimate, researchers have used many different methods, making comparisons

among studies difficult. Reported badger densities range from 0.38/km^2 in Utah (Lindzey 1971) to 5/km^2 in Idaho (Messick and Hornocker 1981). These estimates were derived from systematic trapping schemes. We chose to trap badgers only at known dens rather than along traplines to minimize non-target species captures. Dwellings are more common in the Illinois agricultural landscape than on other reported study sites. Domestic animals could have been frequently captured in traplines, a situation we deemed unacceptable.

The estimated Mason County badger density of 0.14/km^2 is the lowest reported. This is not surprising, since our estimate is based on home range size and overlap, and these are also among the extreme in the literature. The extrapolated home range density estimate for Mason County is probably reliable since the study site included approximately one third of the county. We do not have enough information to further extrapolate these data for the remainder of Illinois.

Of all the techniques we employed to explore badger abundance, aerial surveys represent the best index to relative badger density statewide. Unfortunately, this technique is expensive and in our experience was plagued with logistical problems. Badger digging activity is most visible after crops have been harvested in the fall and prior to crop emergence in the spring. Our flights were made to coincide with activity at red fox dens, which is a small window of opportunity in spring. Unfavorable flying weather was commonly encountered at this time

of year. If similar flights were conducted strictly for recording badger diggings fall or winter flights might be preferable.

The furtrapper survey shows promise as a long-term index to changes in badger abundance. As long as badgers are primarily trapped incidentally, trapping results remain relatively free of pelt price biases. If similar questions were posed to trappers periodically we may be able to detect any major changes in badger density.

So little historical data exist regarding badgers that we can only speculate how current badger density compares to past abundance. Although statewide badger distribution has expanded to include the southern third of Illinois, we suspect that overall badger abundance is lower now than it was prior to European settlement. The modern badger population, at least in Mason County, seems dependent on non-row crop cover types for sufficient food and reliable cover (safe burrows). The tallgrass prairie supported a diverse community of rodents (Madson 1982), many species of which were larger and probably more densely populated than the 3 dominant species occurring in row crops at our study site (Figs. 9 and 10). For instance, Franklin's ground squirrel was a typical tallgrass prairie species and is somewhat colonial (Hoffmeister 1989). The more abundant badger populations reported in studies from the western U.S. relied on prey species such as prairie dogs and ground squirrels which are concentrated in loose colonies, or "towns". The presettlement

prey base of Illinois' tallgrass prairie was probably more similar to those reported in western badger studies, so it is likely that badger density was closer to that reported in those studies. Badger density estimation at a reasonably large intact tallgrass prairie site, such as the Konza Prairie in Manhattan, Kansas, would provide a closer link to past badger density in Illinois. Soils at this site are poorer than they were in the Illinois prairie, and could affect badger prey abundance. But the fact that the prairie and its potential prey community is intact would probably enhance badger numbers. An understanding of badger density at this site might shed further light on relative past and current Illinois badger density.

CHAPTER 4: BADGER LITERATURE DATABASE

American badgers have not been frequently studied in depth and aspects of their distribution and ecology are as yet unknown (Messick 1987). A thorough search to examine all available background information regarding badgers is crucial to present and future research efforts.

We gathered badger literature references with several standard approaches. These included an ongoing computer search of current literature, and searches of: 1) literature cited in papers with badgers as the central subject, 2) indices to key journals such as Journal of Mammalogy and Journal of Wildlife, Management, and 3) literature summaries such as Biological Abstracts and Wildlife Review.

Badger references were entered in a computer software program (Endnote Plus, MS-DOS Version, Niles & Associates, Berekeley, CA). All papers were assigned keywords according to subject. For this report, references were grouped as those with badgers at the central subject, and those with badgers as a peripheral subject. This is a subjective grouping, and may not concur with every reader's appraisal. We directly examined as many publications as possible in an attempt to confirm that *Taxidea taxus* was referenced. However, we did not examine all publications.

Over 550 publications with reference to *Taxidea taxus* were recorded (Appendix A). Of these, 228 were deemed to have *Taxidea*

taxus as a central subject, and are highlighted by bold text in Appendix A. A computer file containing all references will be made available to the granting agency personnel in a form accessible to them.

CONCLUSIONS AND MANAGEMENT RECOMMENDATIONS

CONCLUSIONS

This project has provided insight into the ecology, distribution and abundance of Illinois badgers. The species is distributed throughout Illinois, a considerable range expansion since conversion of the southern forested region to agricultural lands. Population density is much lower than at study sites in the western U.S., and is most likely also lower than it was prior to European settlement. Population density is not uniform throughout the state. Evidence suggests that northwestern Illinois supports relatively higher badger population density and southern Illinois has relatively lower badger density. Our study site in Mason County did not rank as highly as northwestern Illinois in various indices of relative badger abundance. Further data collection, especially from periodic furtrapper surveys, would better illustrate the relationship between northwestern Illinois and the Central Sand Prairie WMU regarding badger density.

Badger food supply and safe cover for burrows are probably limiting, forcing individual badgers to range widely to meet their needs. However, badgers are still able to maintain relatively exclusive home ranges, resulting in low badger density. Nevertheless, populations are sufficiently large for badgers to locate mates and breed consistently and statewide.

Human-induced events, such as vehicle collisions, agricultural equipment accidents, and incidental trap captures

impact mortality. Canid predation on juveniles was significant in our study. Adult male mortality is higher than adult female mortality, although our actual estimates of this parameter are not accurate.

Evidence from burrow cover type choice data and food habits analysis indicate that badgers select habitats with relatively undisturbed soils. Many of these cover types, such as hayfields, fallow fields, CRP fields, and roadsides are "grassland-like". Although native grasslands have disappeared, remaining habitats that echo the prairie's structure, and to some extent its available prey base, help support badgers. Location of burrows relative to linear cover types suggests that badgers use these corridors regularly, although we can not be certain whether corridors are most important as travel lanes, or for foraging and burrow cover.

MANAGEMENT RECOMMENDATIONS

Not surprisingly, the most effective habitat management practice that would benefit badger populations would be to maximize grassland-like habitat. It would be especially useful to provide large blocks of land that can support a healthy prey base of burrowing rodents, such as voles and ground squirrels. An alternative to large single blocks of grasslands would be to group sites of variable size as closely together as possible. The objective is to provide good badger foraging habitat in a configuration that minimizes a need for badgers to move frequently and long distances. Sites of this nature would supply badgers with an environment of relative safety from human-induced

mortality.

The importance of undisturbed corridors to badgers should be interpreted carefully regarding management practices. Although it appears badgers use corridors frequently in Mason County, this may be primarily because they are one of the more widely distributed and frequently encountered undisturbed cover types available. Further study of corridor use, especially in different landscape configurations, is warranted, although this is difficult task.

Direct population management by means of a badger trapping season should be approached cautiously. Although our population model is not ideal, it is based on parameters derived directly from a local badger population. Estimates were made to err on the side of population overestimation, rather than underestimation. In spite of this, the model suggested that even a low trapping rate of 0.045 could have serious negative impacts on badger numbers. It is possible that heavy trapping pressure could extirpate badgers from a small area.

We recommend that if a badger trapping season is opened, it should be conducted on a limited pilot basis. Specifically, limiting trapping to areas of relatively higher badger abundance, such as the Northwest Hills WMU (and possibly nearby counties) would be prudent. It would be helpful to simultaneously collect additional information on local trapping effort and badger sex and age statistics. Trapping should be regularly monitored and evaluated for badger population impacts before expanding the season limits.

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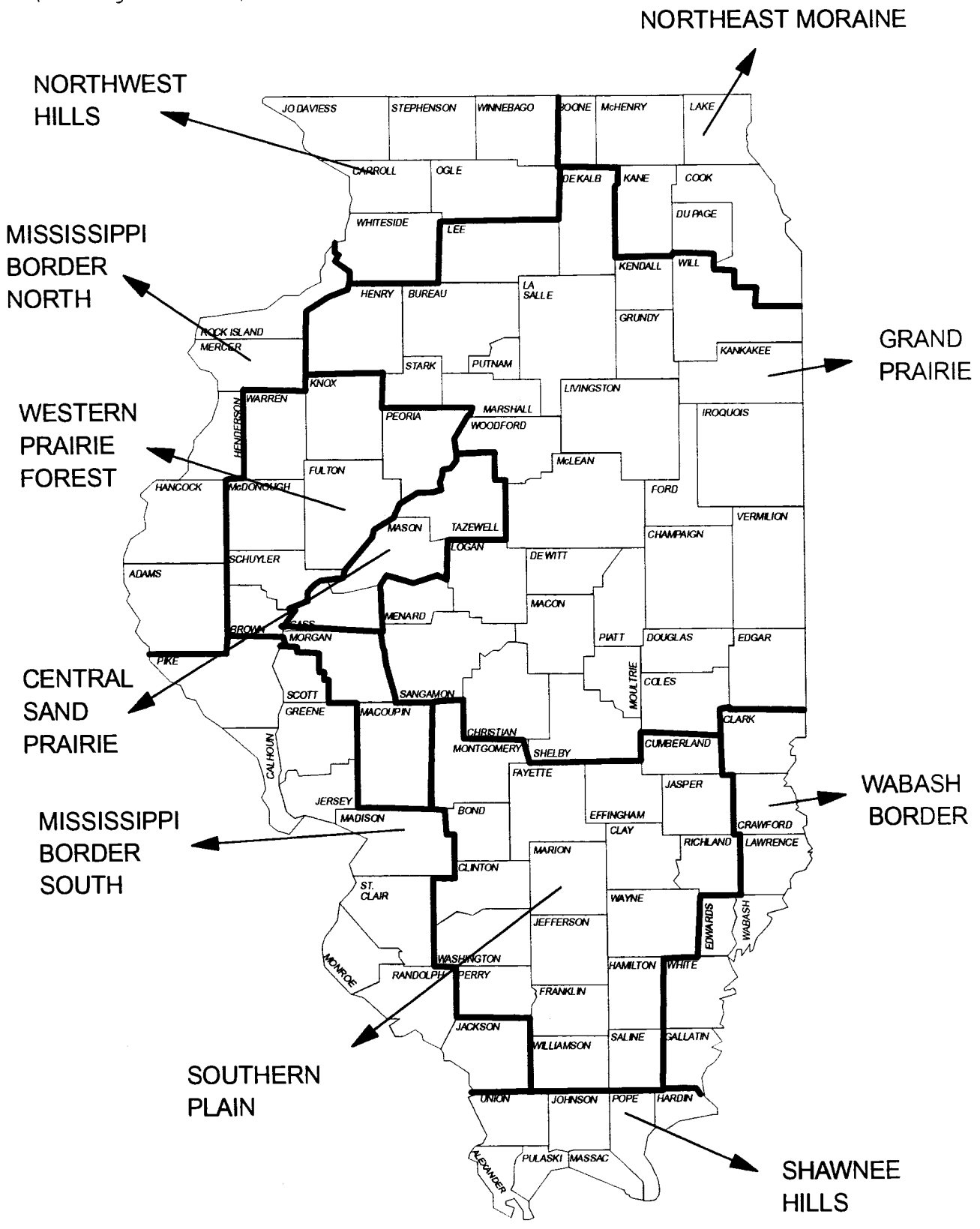
ACKNOWLEDGEMENTS

This project would not have been successful without the assistance of many individuals. G.F. Hubert, Jr. and B. Bluett provided excellent advice during the entire project. For their diligent and conscientious field work we thank B. Fulk, M. Georgi, C. Hine, S. Horn, G.R. Lang, M. Miller, J. Seets, E. Smith and D. Upp. The entire staff at Forbes Biological Station (INHS) contributed much needed and appreciated support throughout the project. J. Seets assisted ably with badger necropsies. W.R. Anderson offered excellent advice on conducting written surveys and provided data as well. T. Beissel and J.M. Ver Steeg generously shared badger sighting and necropsy data. J.P. Messick and S.C. Minta gave helpful advice on techniques for studying badgers. D.A. Hamilton allowed us to use aspects of a river otter population model. Our work benefited from informal discussions with many biologists, including B. Bluett, S. Havera, G.F. Hubert, Jr., and J.M. Ver Steeg. Staff at INHS, IDNR, and IDOT provided frequent and useful badger sighting reports. We thank J.M. Ver Steeg for helpful comments on this manuscript.

Figure 1. Location of badger study site in West-Central Illinois.

Figure 2. Wildlife management units in Illinois (Hubert 1977). Divisions are based in part on natural divisions of Illinois (Schwegman 1973).



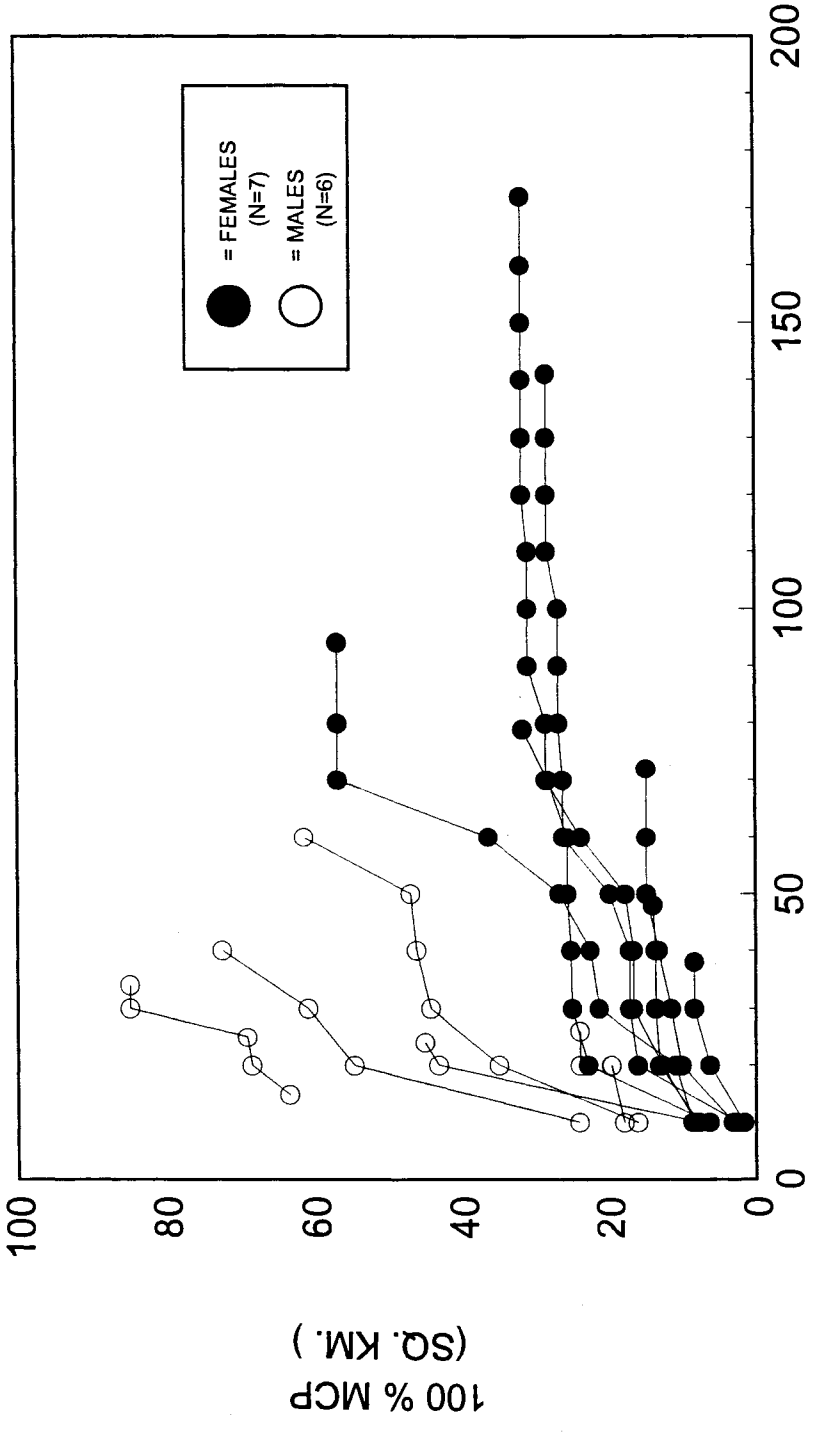


Figure 3. Home range size and sample size for 13 adult badgers.

Figure 4. Locations for male badger #1, illustrating apparent shift in home range.

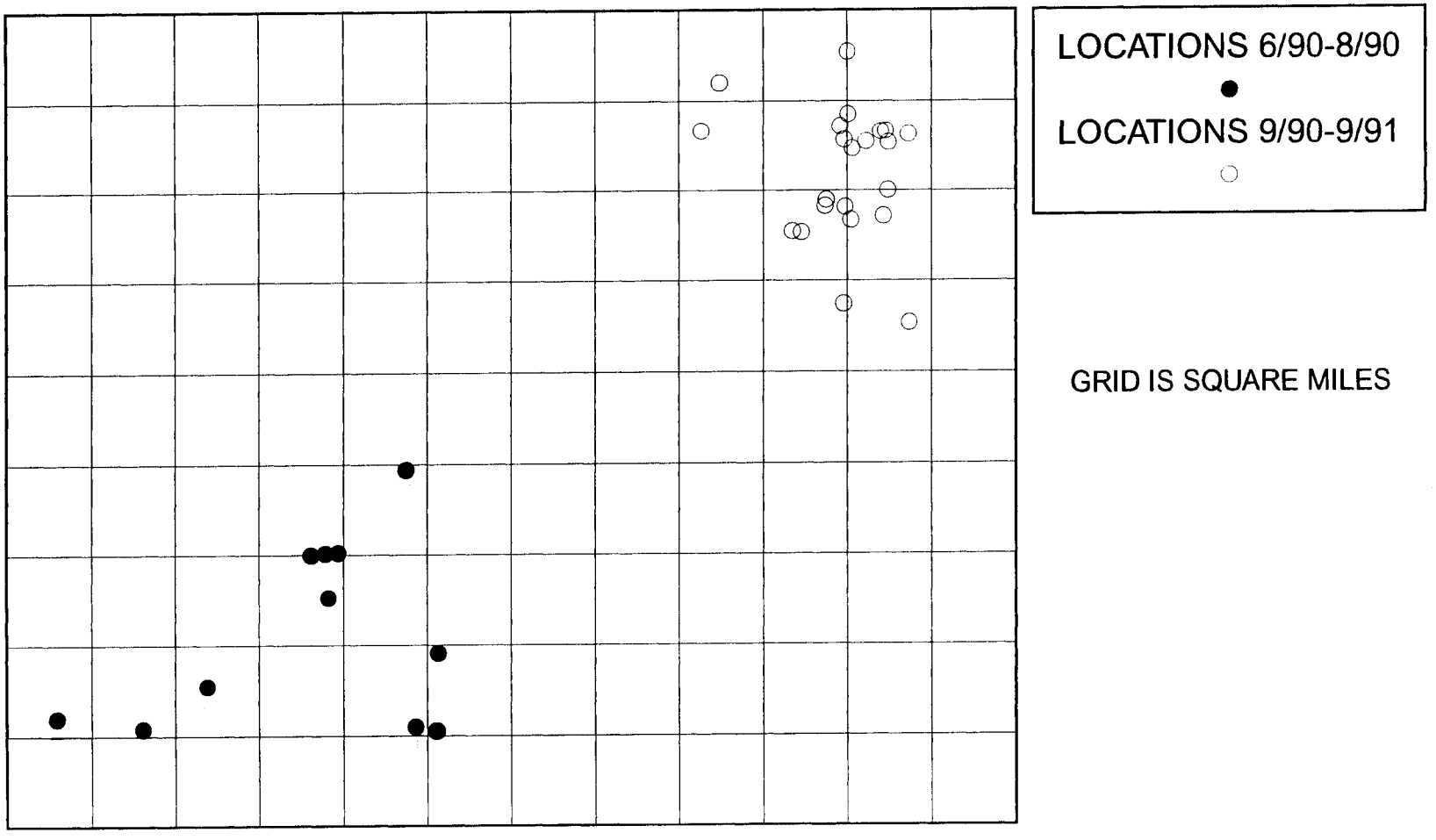


Figure 5. Minimum 24-hour movements by adult badgers. In each period, only badgers with 5 or more recorded movements were included. N = number of badgers in summary.

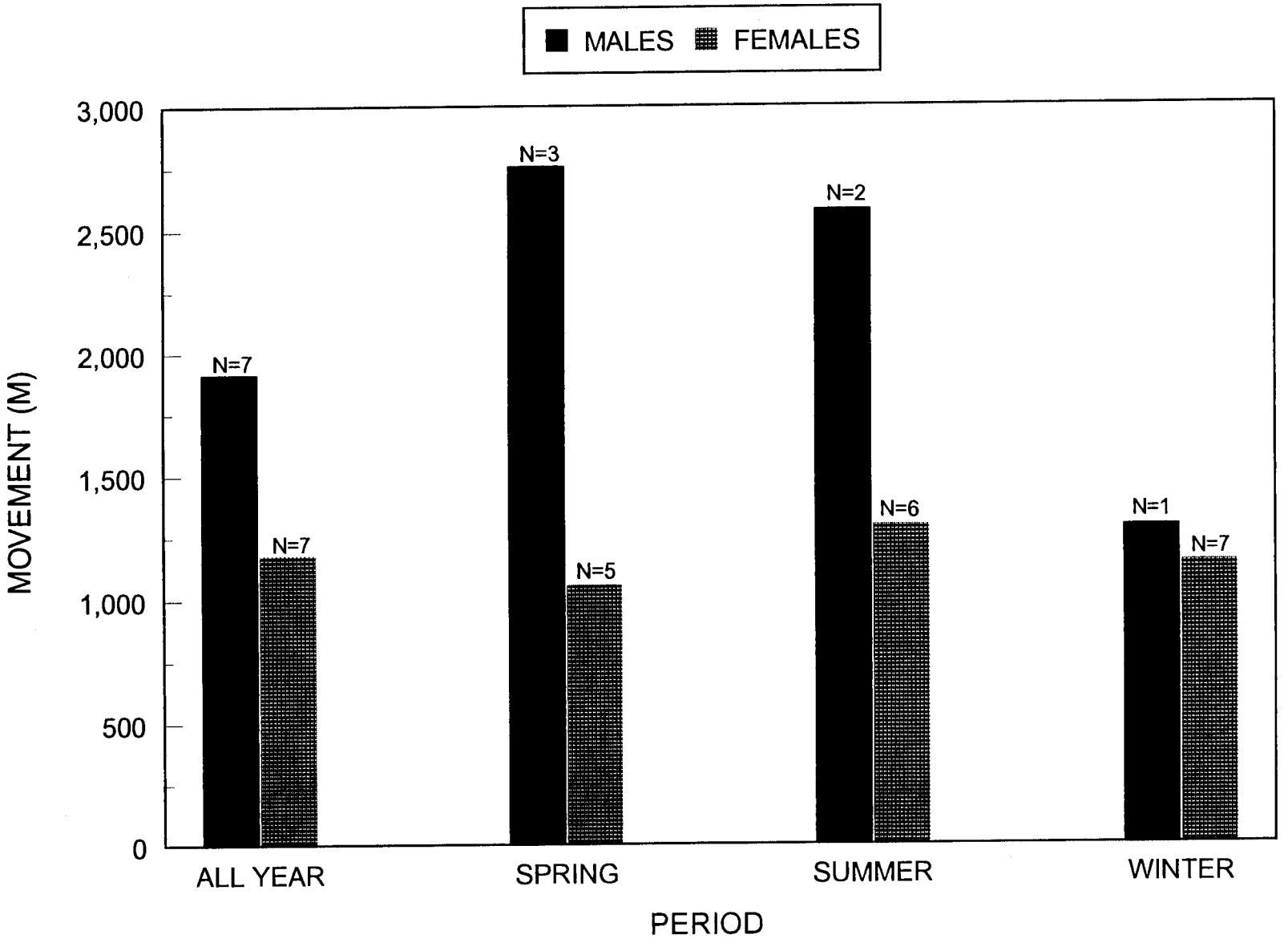
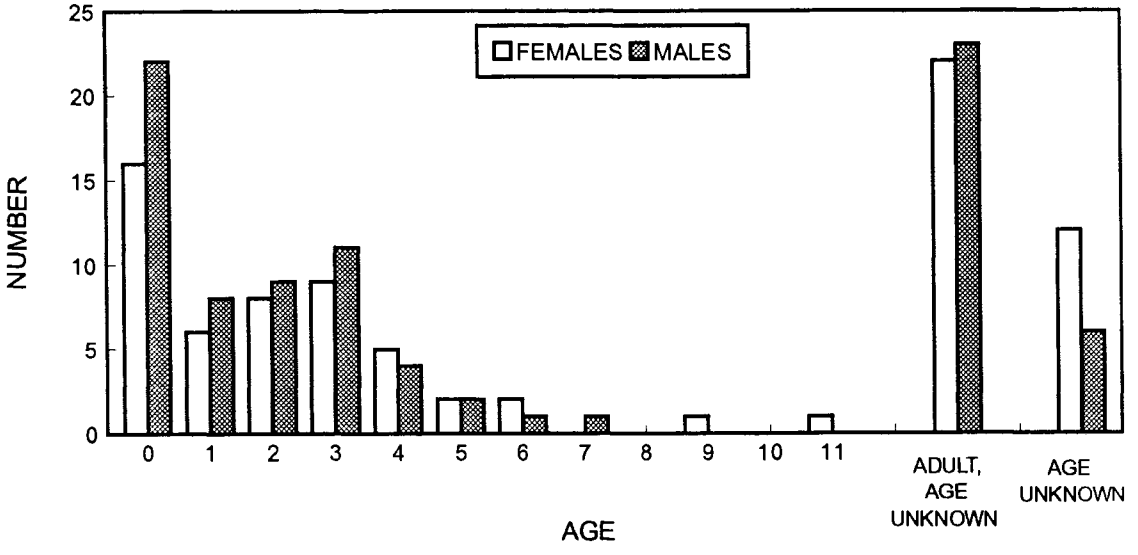


Figure 6. Age distributions of A) badger carcasses collected in Illinois, and B) badgers captured at study site (age at capture).

A



B

Figure 7. Sex ratio of 2 badger samples.

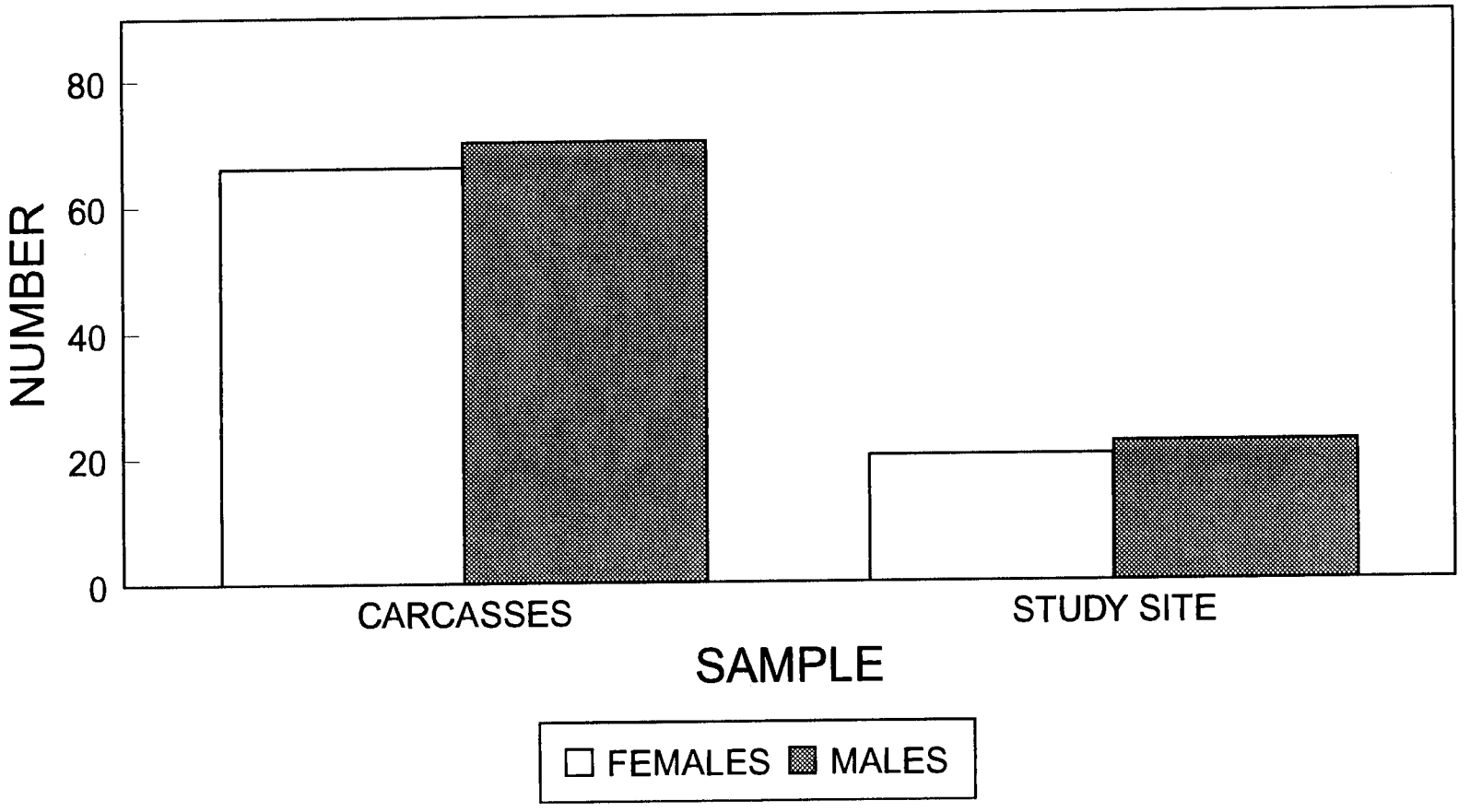


Figure 8. Summaries of reproductive variables for badgers at study site.

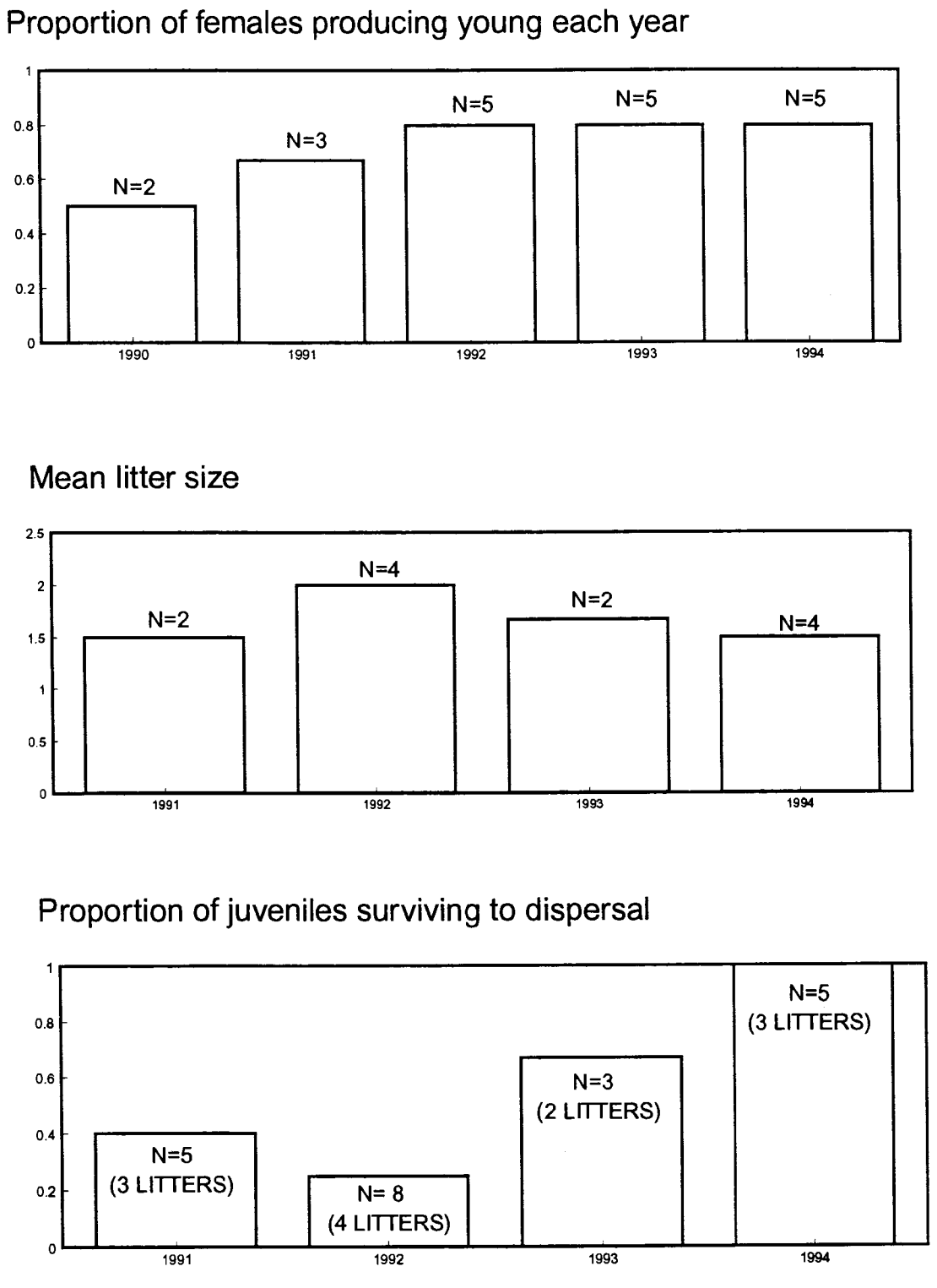
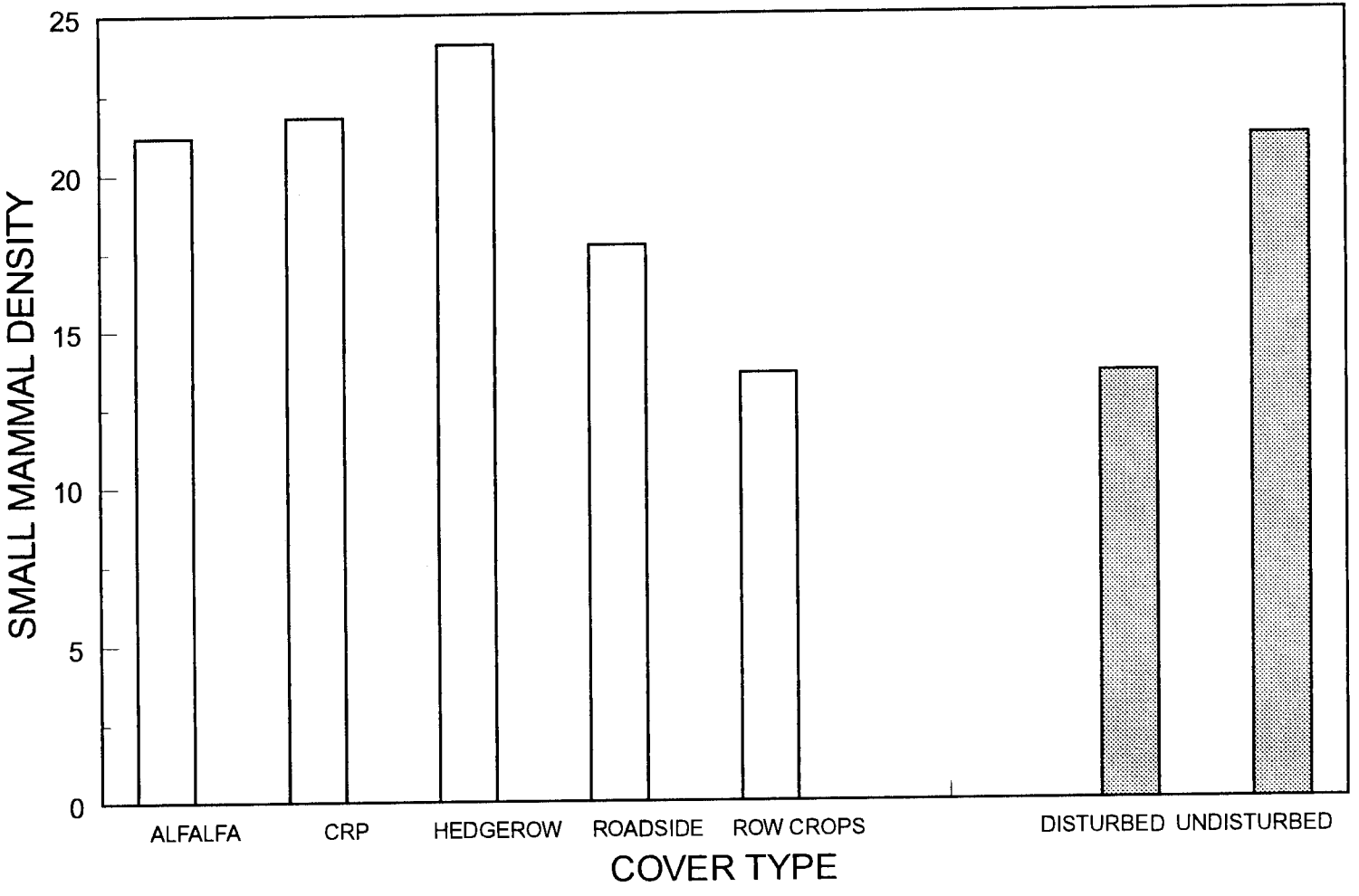


Figure 9. Potential badger prey density in various cover types. Density is number of indivduals per hectare. Disturbed cover types are row crops, undisturbed cover types include all other cover types listed. See text for explanation of cover categories



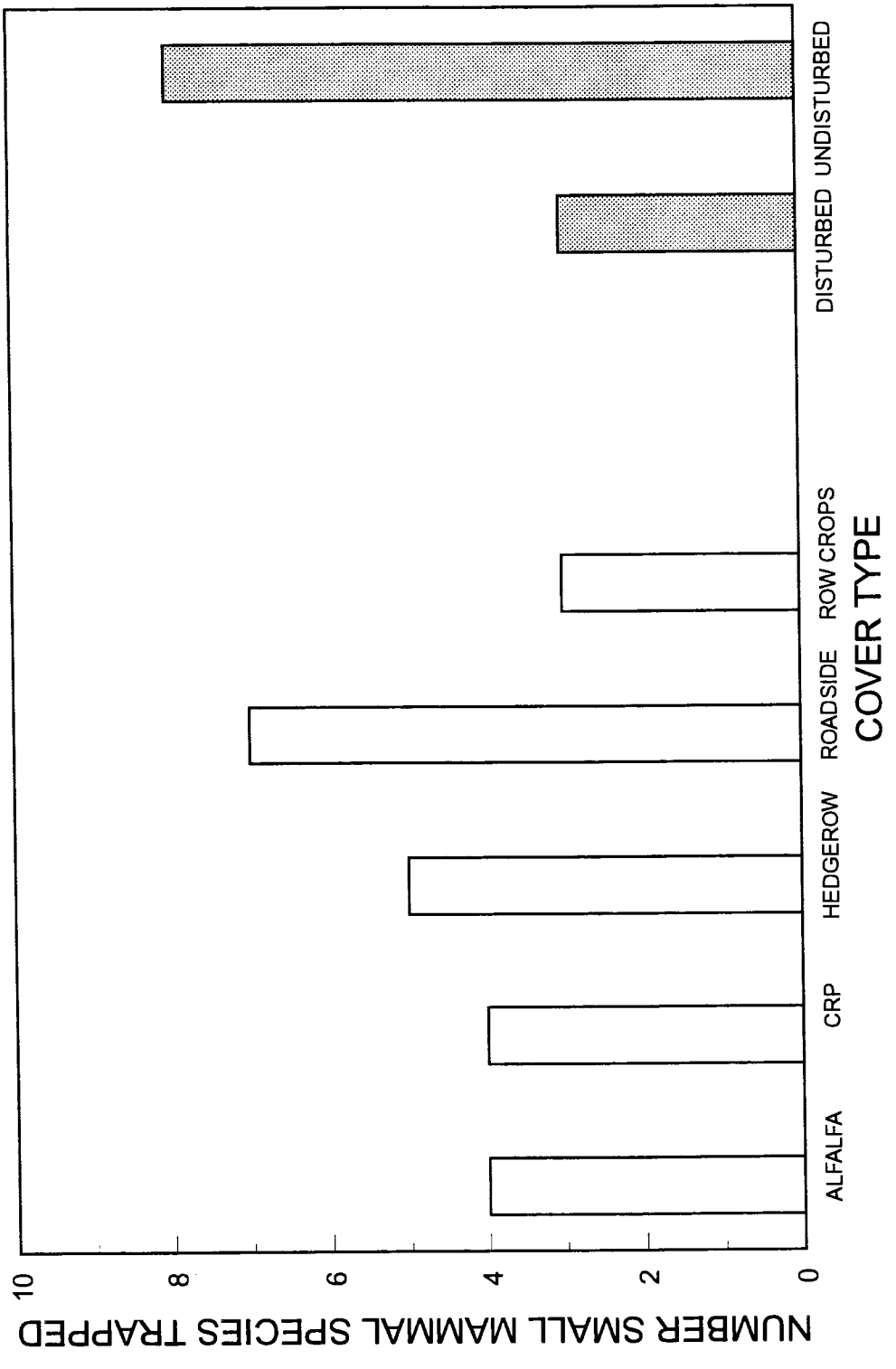


Figure 10. Number of potential badger prey species in various cover types.

Figure 11. Weight range for small mammal species captured (Schwartz and Schwartz 1981). Species abbreviations are: *Blbr = Blarina brevicauda, Mioc = Microtus orchrogaster, Mumu = Mus musculus, Pele= Peromyscus leucopus, Pema = Peromyscus maniculatus, Reme = Reithrodontomys megalotis, Sptr = Spermophilus tridecemlineatus, Zahu = Zapus hudsonius.*

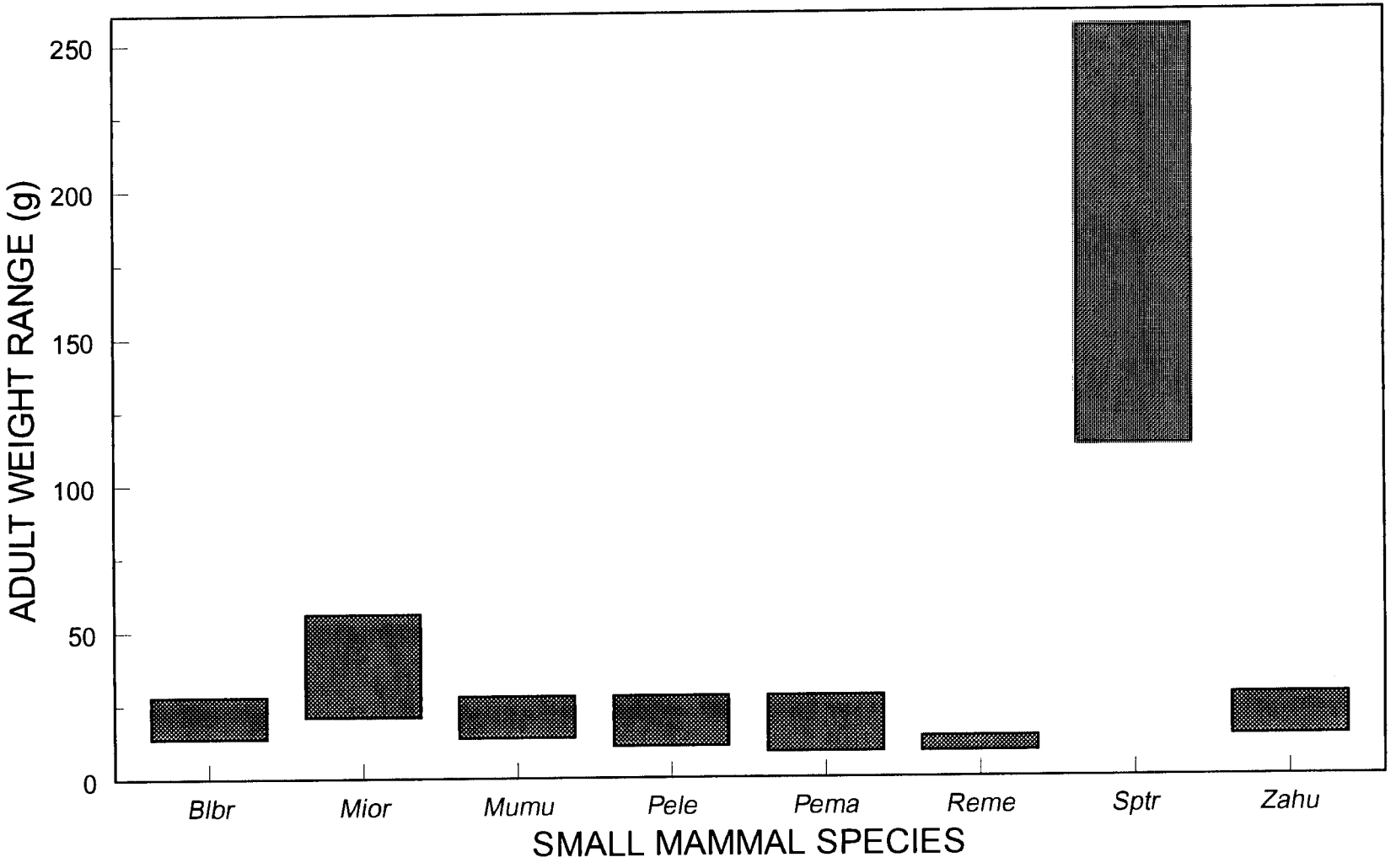


Figure 12 . Cover availability and use for badger burrows. Disturbed cover types are fields regularly plowed, such as corn, soybeans, and small grains. Undisturbed cover types include hedgerows, roadsides, hayfields, and woodlots. Burrow cover type was recorded for 5 adult male and 7 adult female badgers. Cover availability was percent of cropland in each category, as calculated from Census Bureau 1992 data.

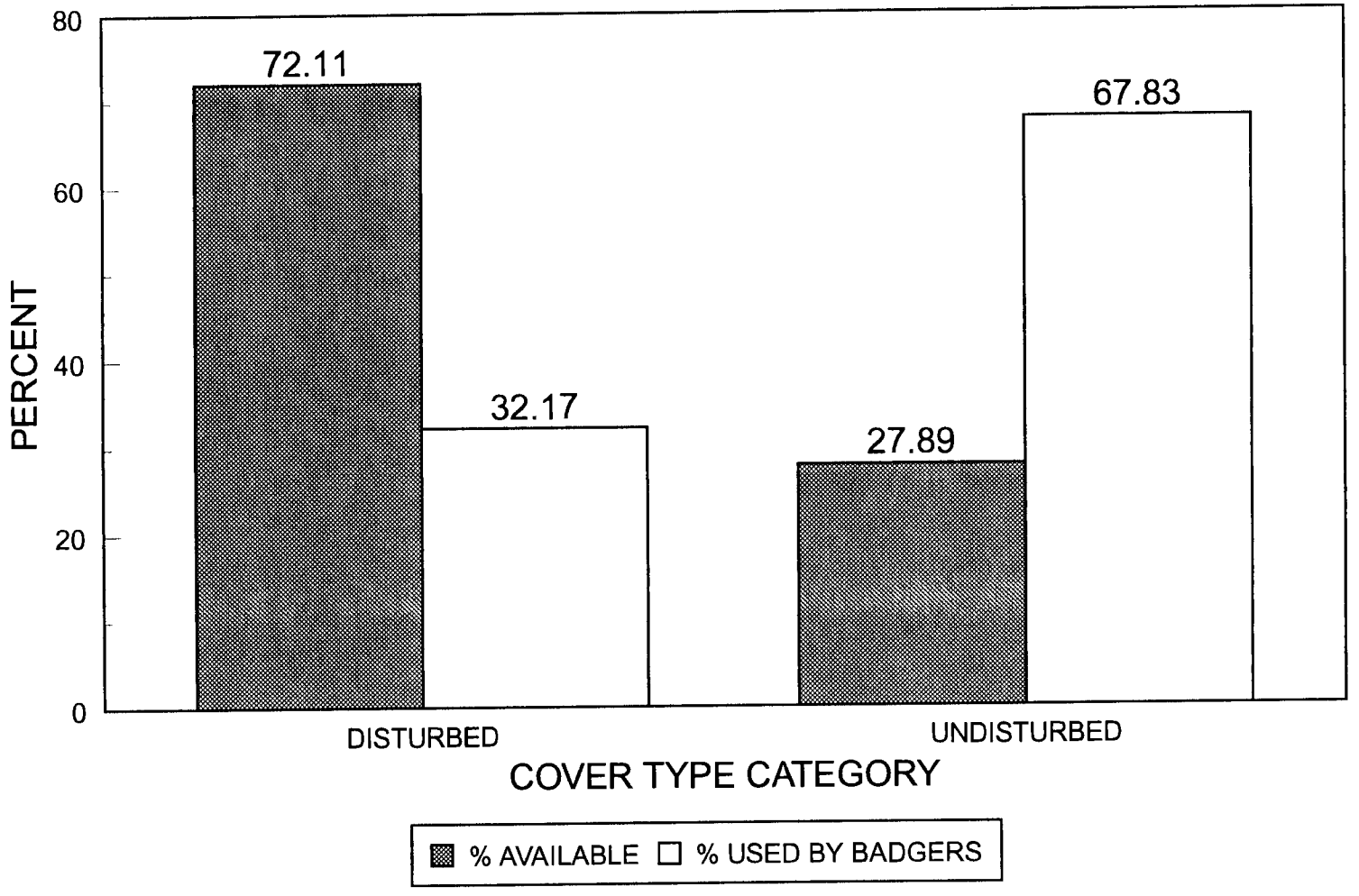


Figure 13. Badger population model results under 3 scenarios.

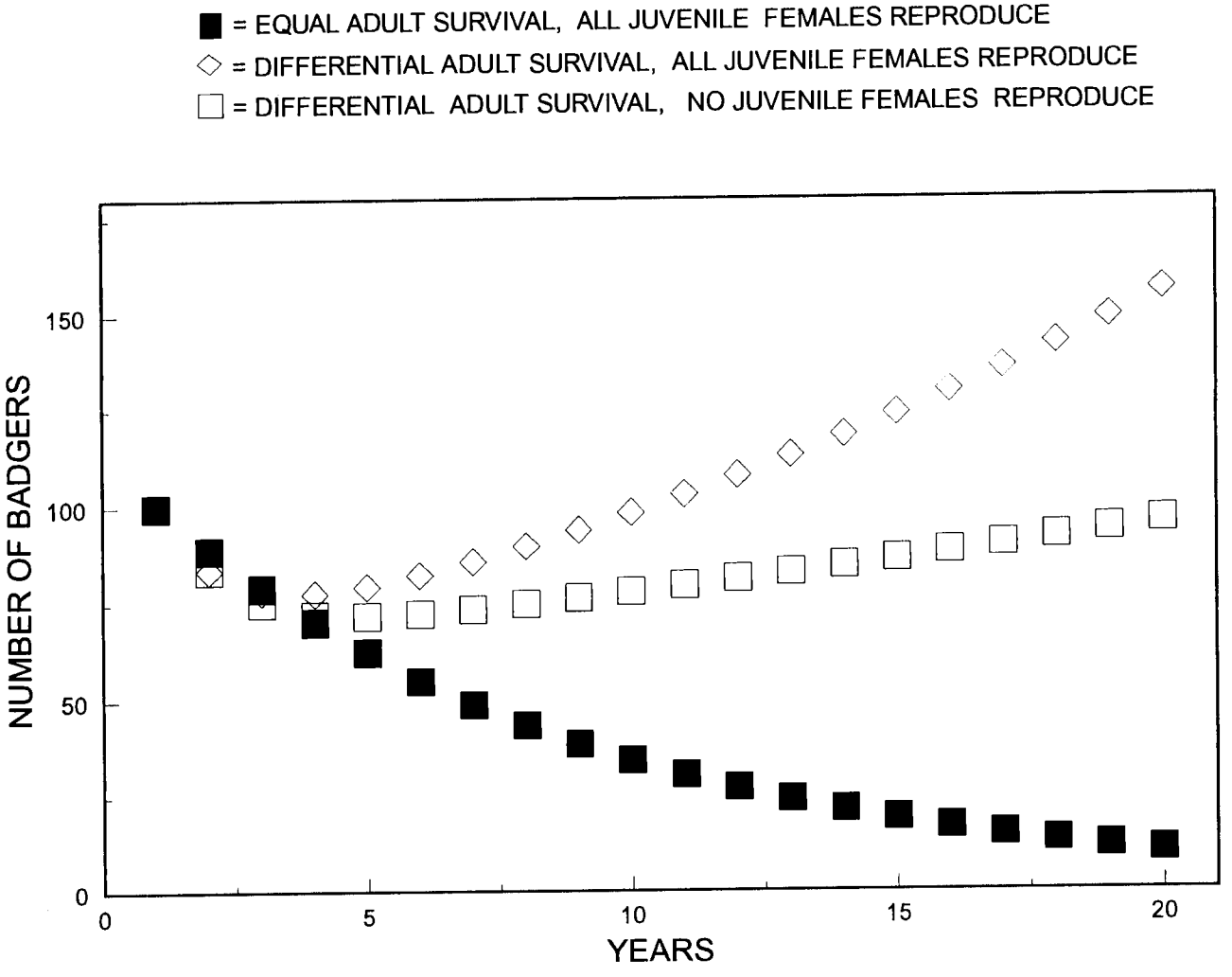


Figure 14. Badger population model results with differential adult survival and all juvenile females reproducing; adult male and female population components are illustrated.

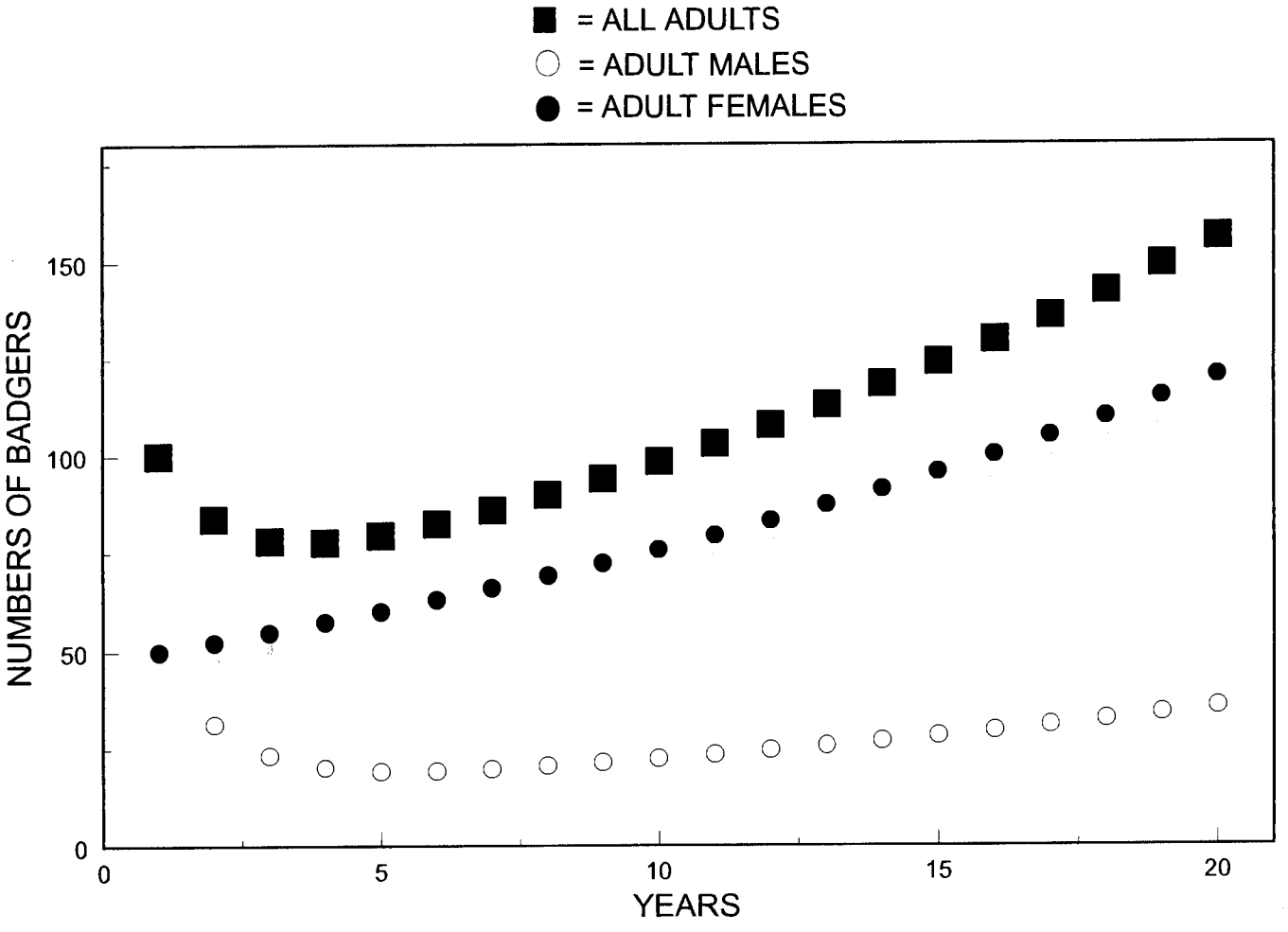


Figure 15. Badger population model results with differential adult survival and no juvenile females reproducing; adult male and female population components are illustrated.

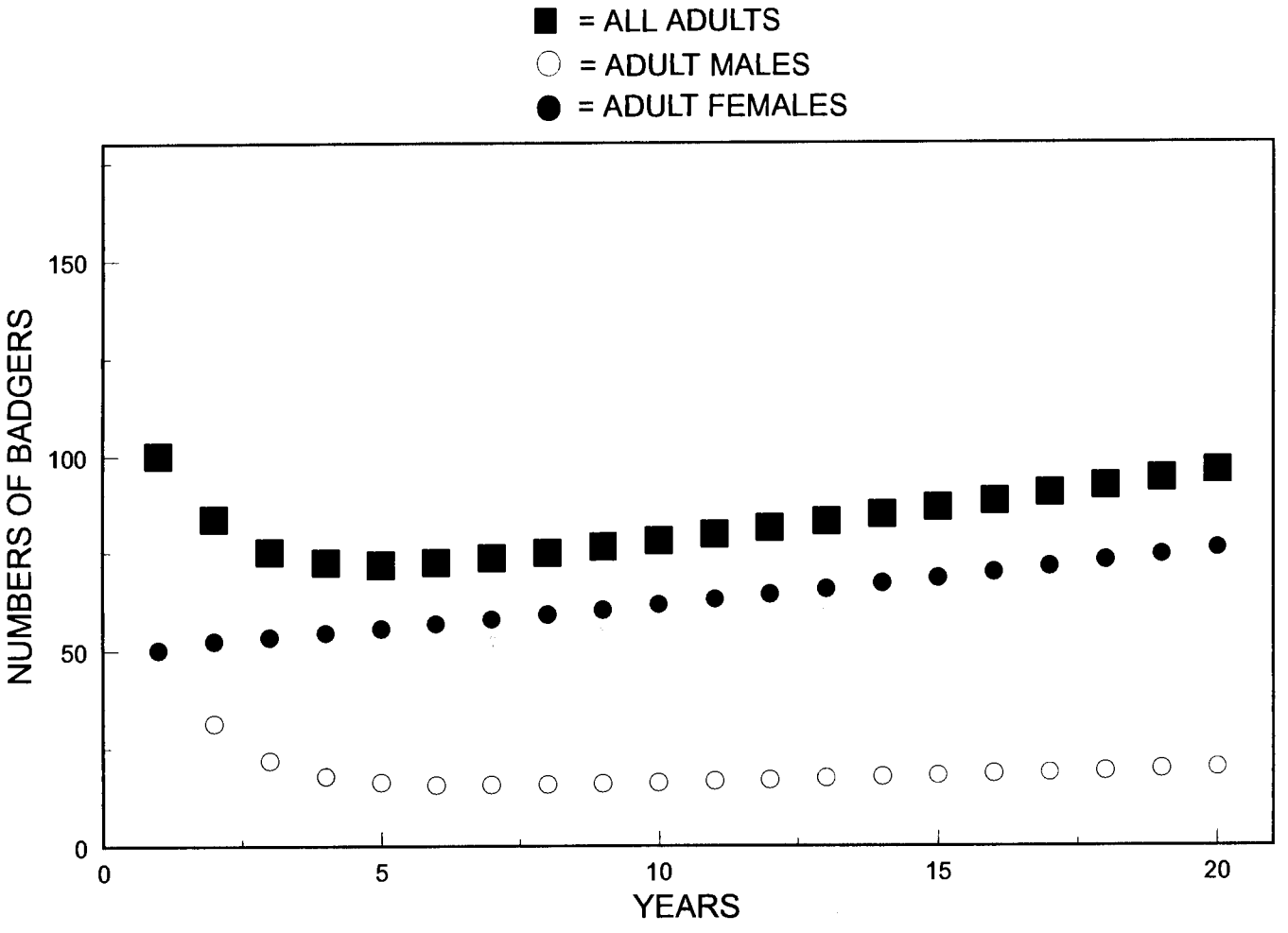


Figure 16. Badger population model results with differential adult survival and all juvenile females reproducing. Two management scenarios are illustrated.

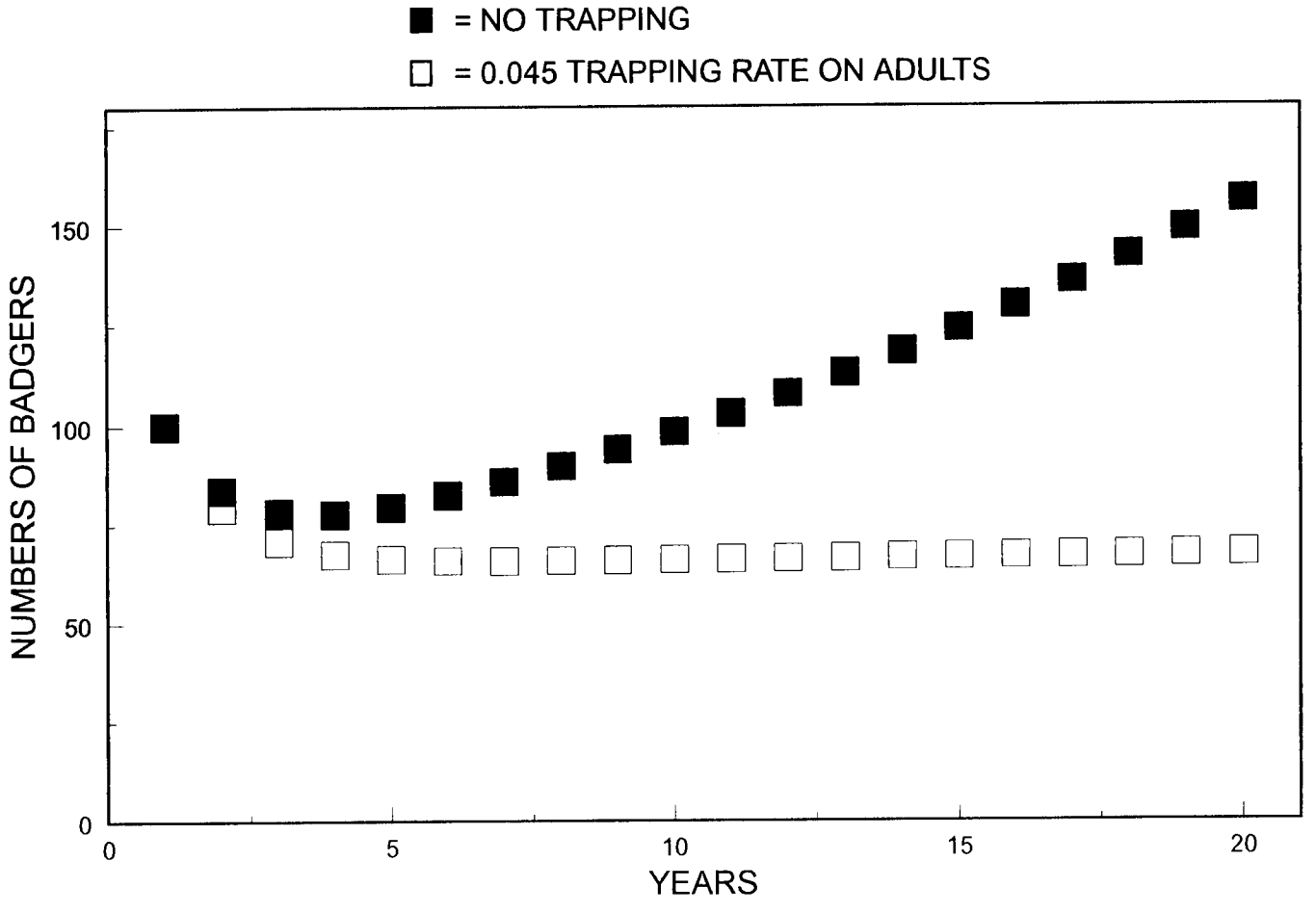
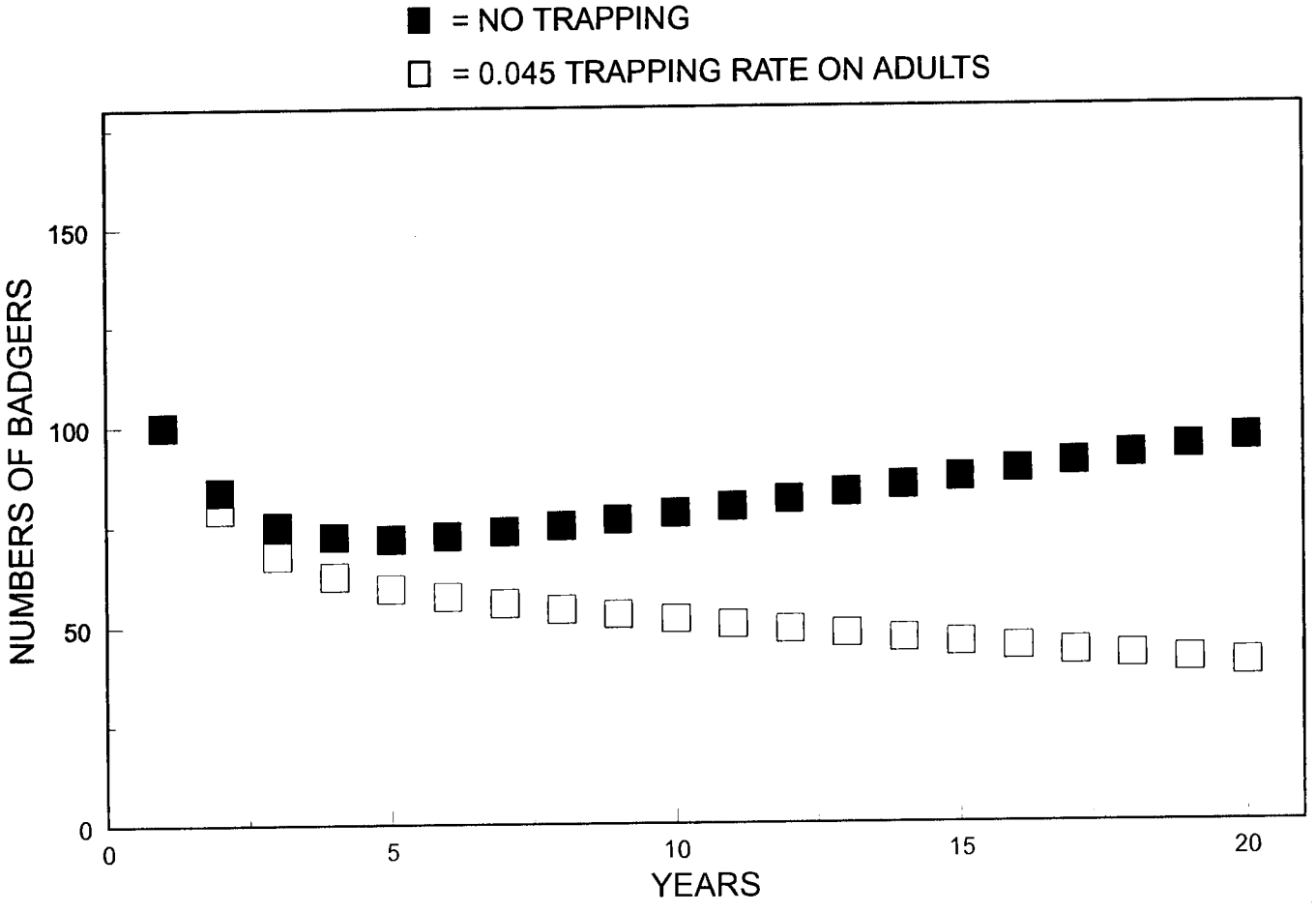


Figure 17. Badger population model results with differential adult survival and no juvenile females reproducing. Two management scenarios are illustrated.



Return to:
George Hubert
Division of Wildlife Resources
Illinois Department of Conservation
P.O. Box 728
Hinckley, IL 60520

ILLINOIS BADGER INFORMATION REPORT

_____
(Reporting date)

Filed by (name & address):

Date of observation:_____

Location (include county-township/range-section and landmarks if possible):

REMARKS: _____

_____

Evidence observed:

___ Live badger(s)

___ Badger carcass Carcass collected[1] ___Yes ___ No

___ Active badger den

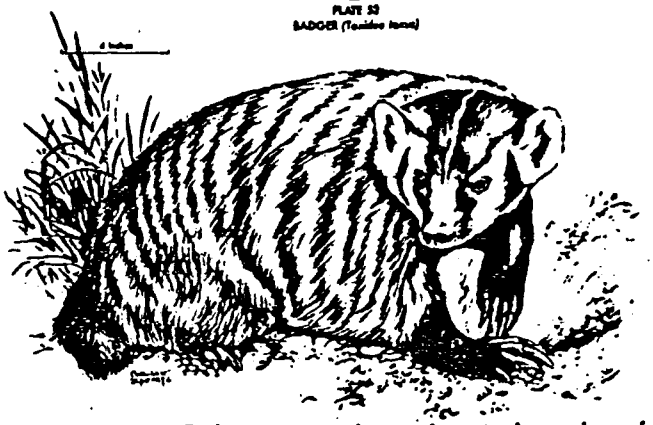
___ Second-hand information (please provide name(s)/address(es) of individuals who reported badger evidence to you:

[1] Contact George Hubert (815-286-7434) or Dick Warner (217-333-5199) to arrange for pick-up of carcass.

Figure 18. Badger sighting report form provided to Illinois Department of Natural Resources personnel.

WANTED:

Reports on Sightings of the Badger



The North American Badger is a stocky, medium-sized member of the weasel family of mammals. Look for these characteristics:

- √ Gray to yellowish-brown in color with black patches on the cheeks and a conspicuous white stripe on top of the head. The stripe extends nearly to the nose and runs down the neck and back.
- √ Adults weigh 12–25 pounds and have a total body length of 20–30 inches.
- √ The legs and tail are short, and the front feet have long, curved claws.
- √ Very active digger. The conspicuous burrows often measure a foot in diameter, and usually have a large mound of soil at the entrance.
- √ Most often seen above ground at dawn or dusk. Because of their shaggy fur, loose skin, and short legs, badgers appear to "flow" along the ground.

Please report the exact location of all sightings or badger digging activity to:

Illinois Department of Conservation
Division of Wildlife Resources
Trapper Education Coordinator
524 South Second Street
Springfield, IL 62794-9990

ILLINOIS BADGER REPORT

1. What type of badger sighting(s) are you reporting?
   _____ Observed alive _____ Observed dead _____ Digging activity/dens
2. What is the location of your sighting(s)?
   COUNTY _____ NEAREST TOWN _____
3. What is the approximate date of the sighting(s)?
   MONTH _____ YEAR _____
4. In case we need to contact you for more information, please include the following:
   NAME _____ PHONE _____
   ADDRESS _____
5. Comments _____

Figure 19. Poster used to request badger sightings. Original poster was 11 by 17 inches.

Figure 20. Distribution of confirmed badger sighting reports among different sources. IDNR = Illinois Department of Natural Resources, Posters = cards returned from informationanl posters, INHS = Illinois Natural History Survey, IDOT = Illinois Department of NTransportation.

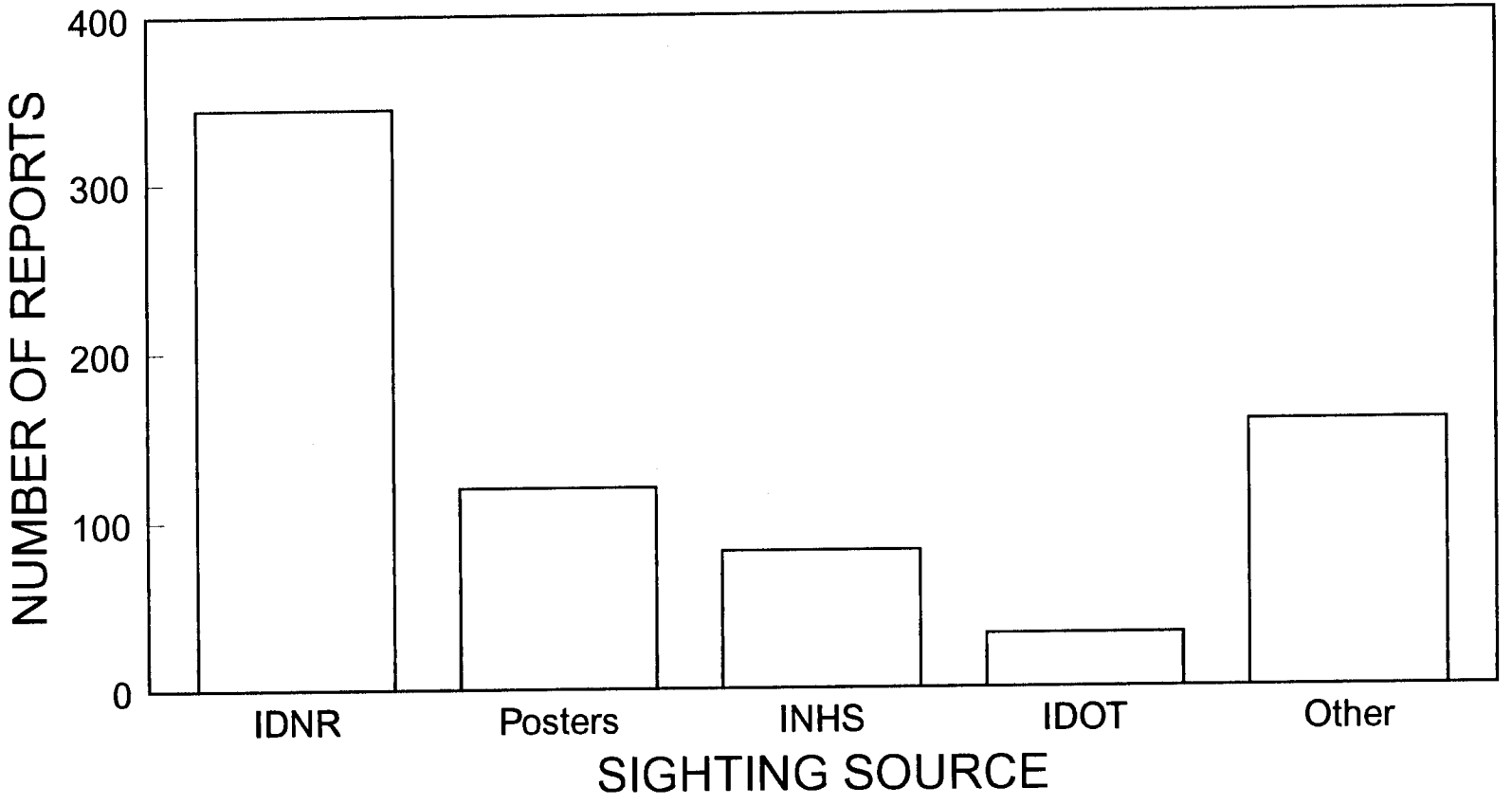


Figure 21. Distribution of badger sighting reports among years.

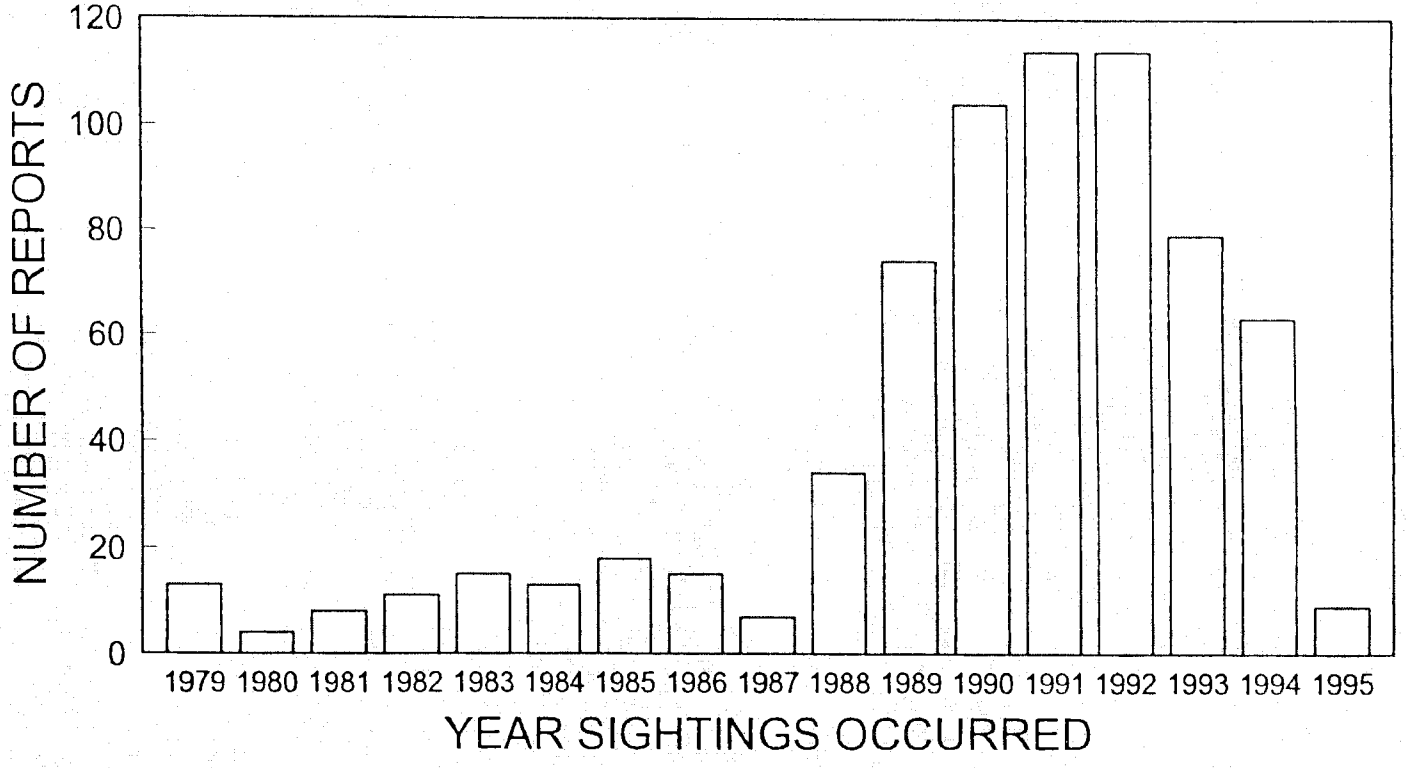


Figure 22. Distriubtion of badger sightings since 1979, not including information from archery hunter or trapper surveys.

= Badger sighting confirmed

= Badger sighting not confirmed

Figure 23. Distribution of reports with confirmed evidence of breeding badgers.

= Breeding confirmed

= Breeding unconfirmed

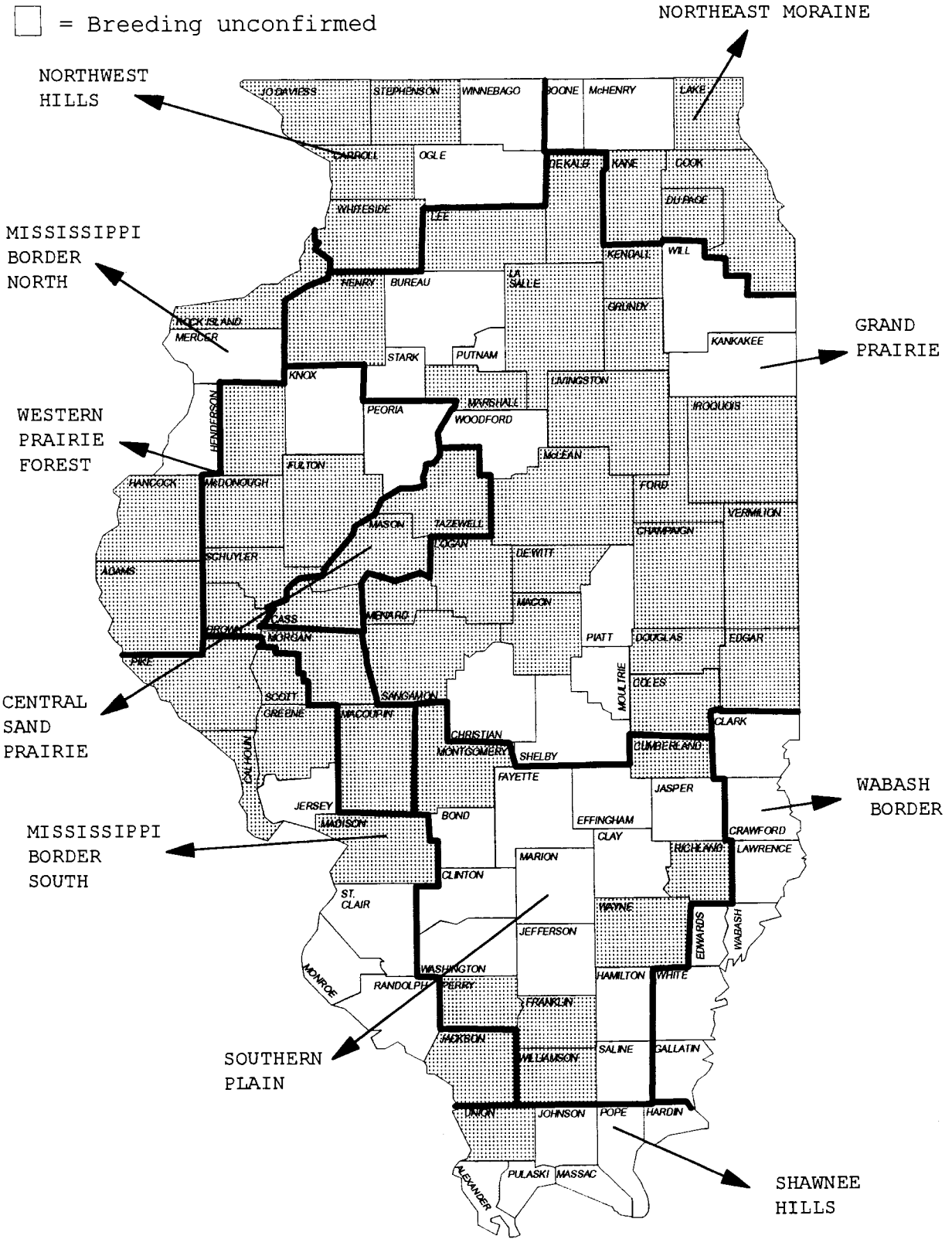


Figure 24. Frequency distribution of number of badger sightings per county.

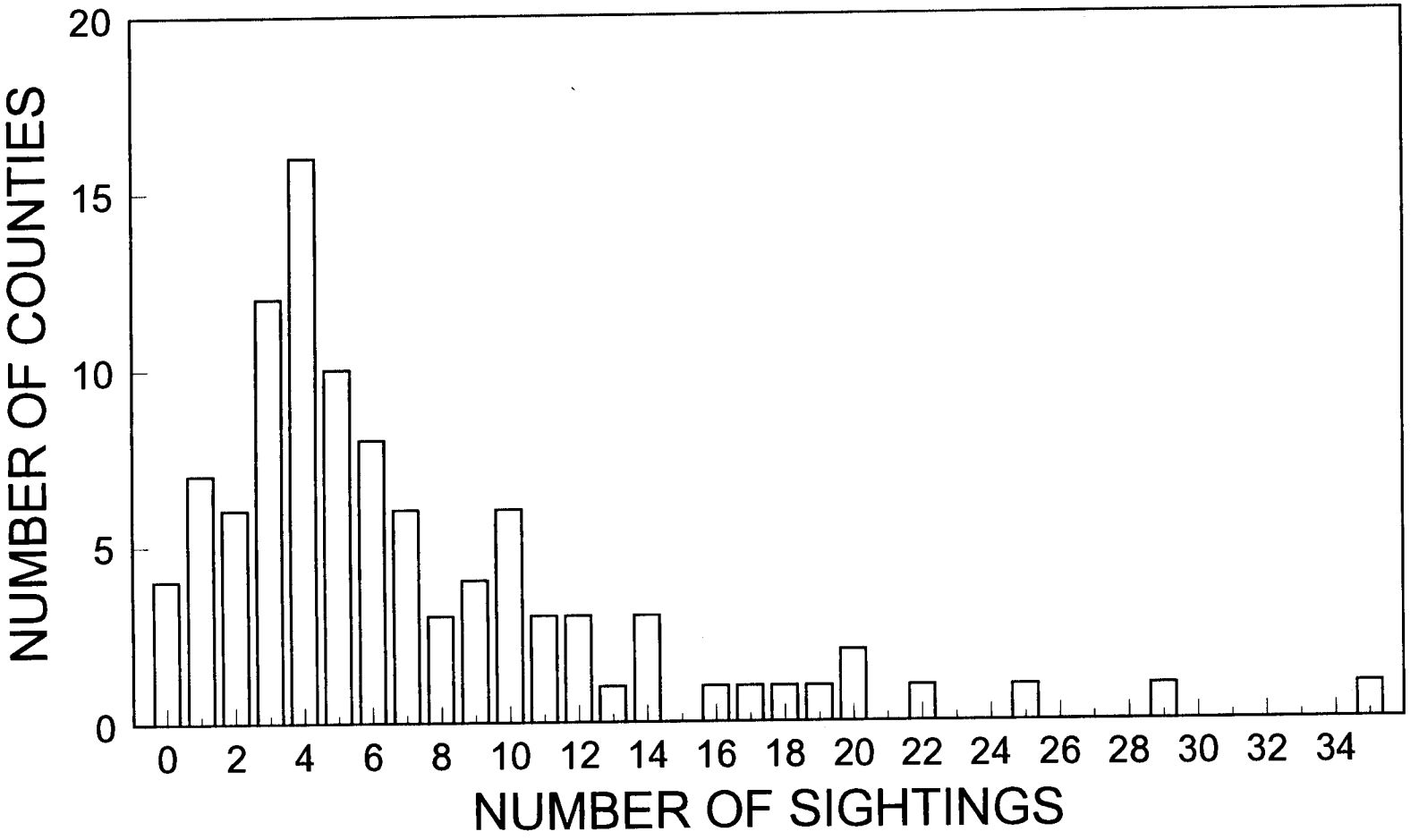
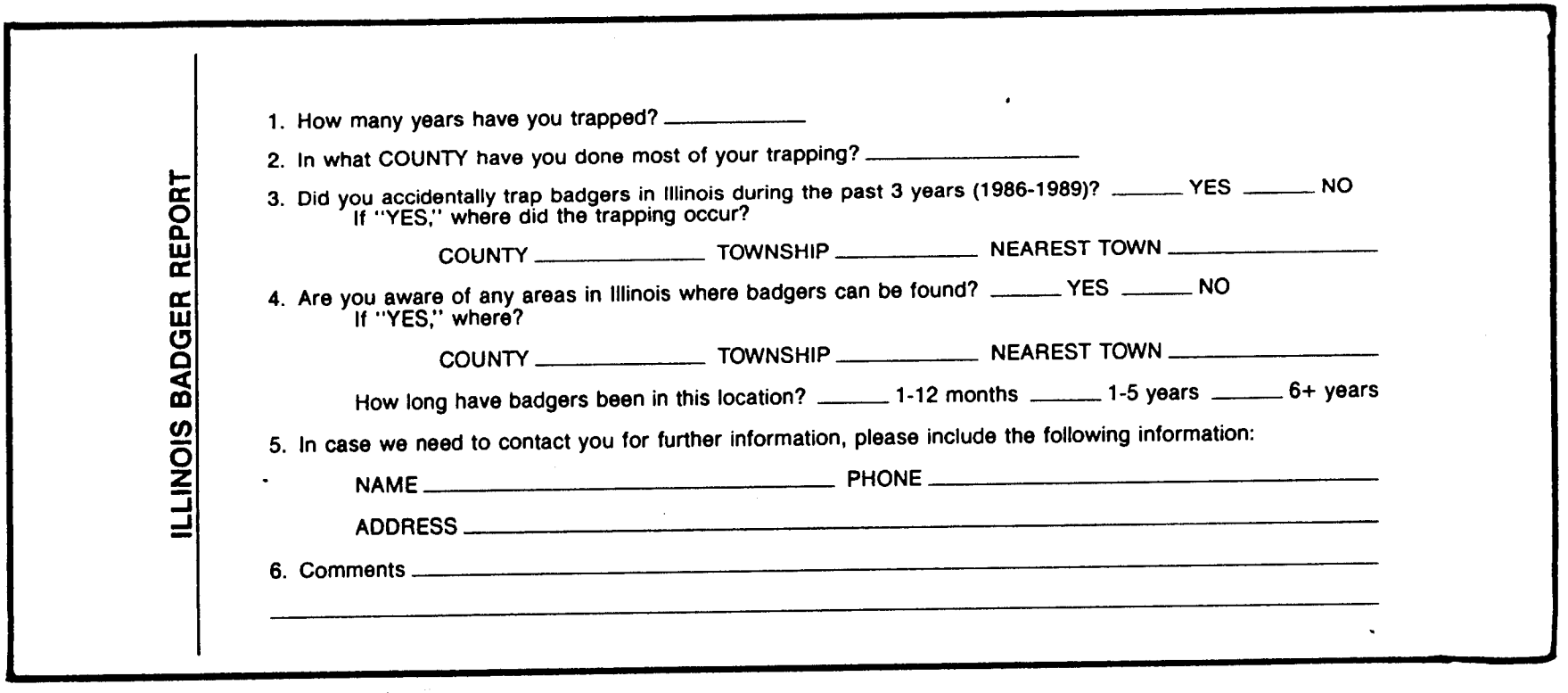


Figure 25. Survey mailed to 2400 furtrappers following the 1989 trapping season. Survey was printed on a postage-paid return card to encourage response.



ILLINOIS BADGER REPORT

1. How many years have you trapped? _____
2. In what COUNTY have you done most of your trapping? _____
3. Did you accidentally trap badgers in Illinois during the past 3 years (1986-1989)? _____ YES _____ NO
   If "YES," where did the trapping occur?
   COUNTY _____ TOWNSHIP _____ NEAREST TOWN _____
4. Are you aware of any areas in Illinois where badgers can be found? _____ YES _____ NO
   If "YES," where?
   COUNTY _____ TOWNSHIP _____ NEAREST TOWN _____
   How long have badgers been in this location? _____ 1-12 months _____ 1-5 years _____ 6+ years
5. In case we need to contact you for further information, please include the following information:
   NAME _____ PHONE _____
   ADDRESS _____
6. Comments _____

PART 3 - FURBEARER POPULATIONS

6. Compared to 1992-93 (last season), were the populations of the following furbearers up, unchanged, or down during 1993-94 (this season)? *(Express your opinion by circling the appropriate number for each species)*

Species	Up	Unchanged	Down	Don't Know
Muskrat	1	2	3	4
Raccoon	1	2	3	4
Red fox	1	2	3	4
Beaver	1	2	3	4
Coyote	1	2	3	4

7. Did you accidentally trap any badgers in Illinois during the past three years (1990-1993)?

Yes . . . 1 No . . . 2 If yes, list county: _____

8. Have seen a river otter or observed river otter sign in Illinois during the past three years?

Yes . . . 1 No . . . 2 If yes, list county: _____

9. Have seen a bobcat or observed bobcat sign in Illinois during the past three years?

Yes . . . 1 No . . . 2 If yes, list county: _____

PART 4 - FURBEARER HUNTING

9. Did you also HUNT furbearers with a gun and/or dogs during the 1993-94 season?

Yes . . . 1 No . . . 2

If yes, please give the number of each kind taken:

_____ Raccoon _____ Red Fox _____ Skunk

_____ Opossum _____ Gray Fox _____ Coyote

THANKS FOR YOUR COOPERATION!!!

NO POSTAGE REQUIRED

Figure 26. One page of furtrapper survey conducted by Illinois Department of Natural Resources following 1993 trapping season. Question 7 was added for information on incidental badger trapping.

Figure 27. Distribution of counties with high numbers of badger reports during the course of the study.

= < 15 badger sightings = ≥ 15 badger sightings

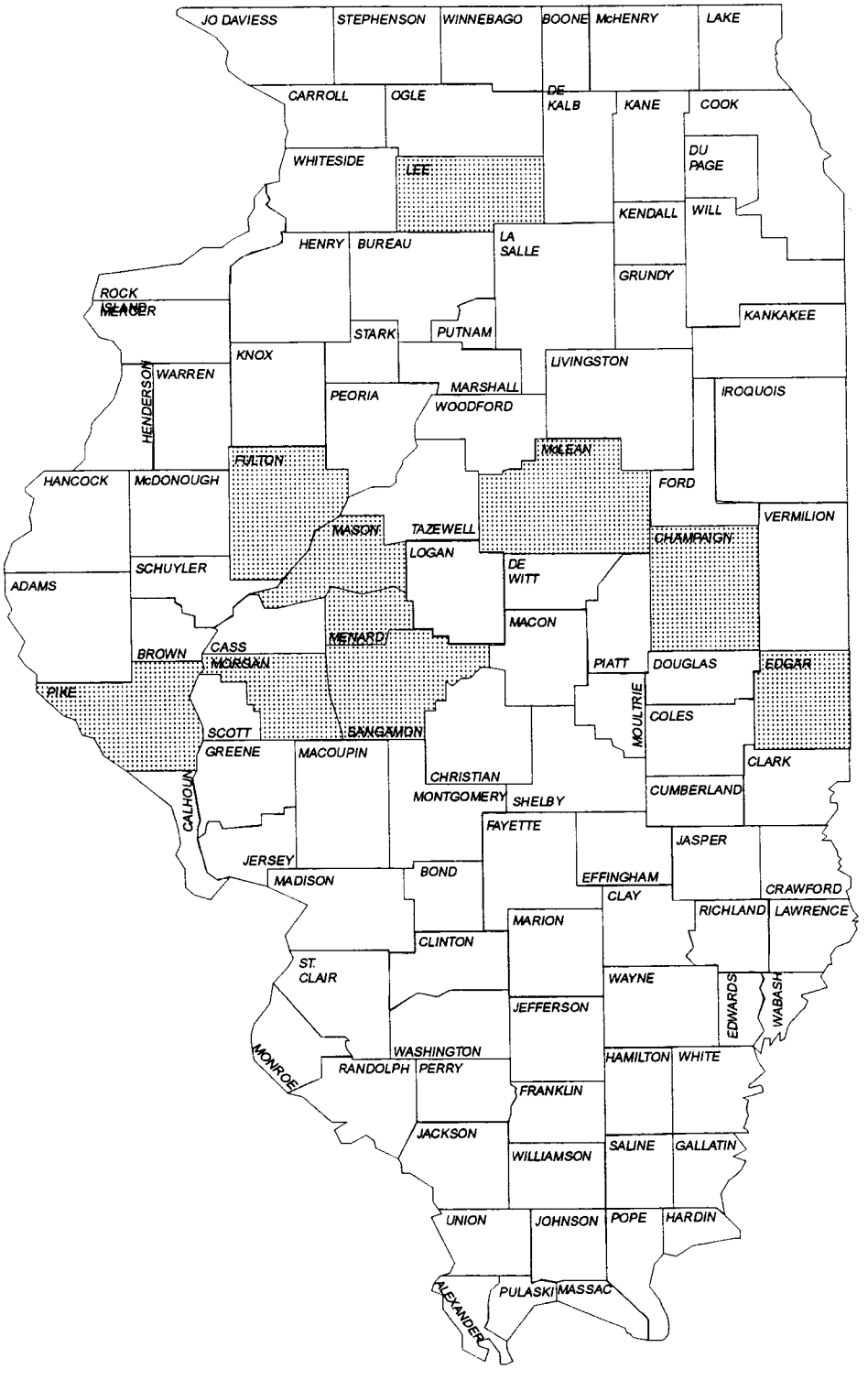


Figure 28. Distribution of incidental badger trapping reports from 1989 trapper survey.

= No badgers trapped = Badger(s) trapped

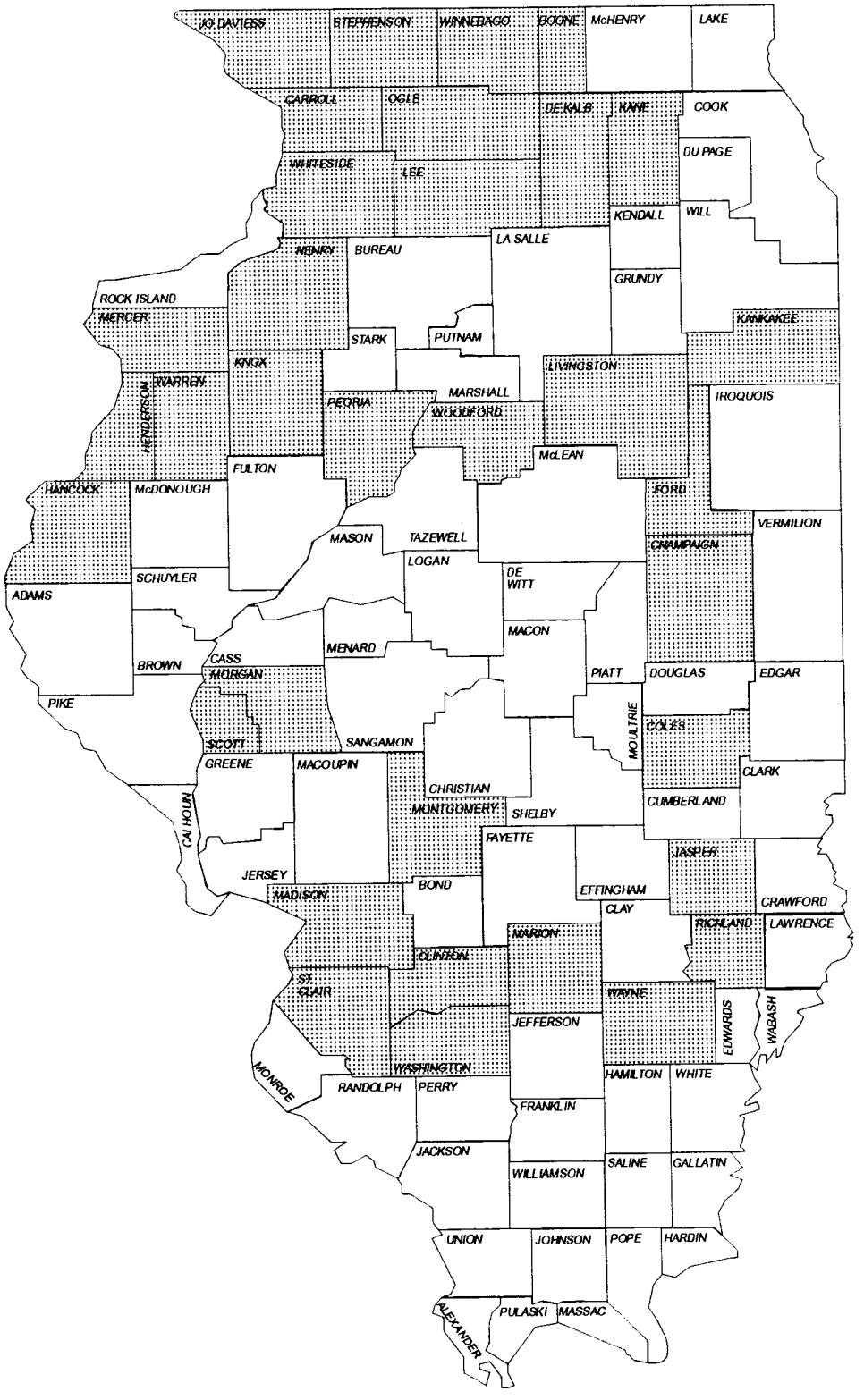


Figure 29. Distribution of incidental badger trapping reports from 1993 trapper survey.

= No badgers trapped = Badger(s) trapped

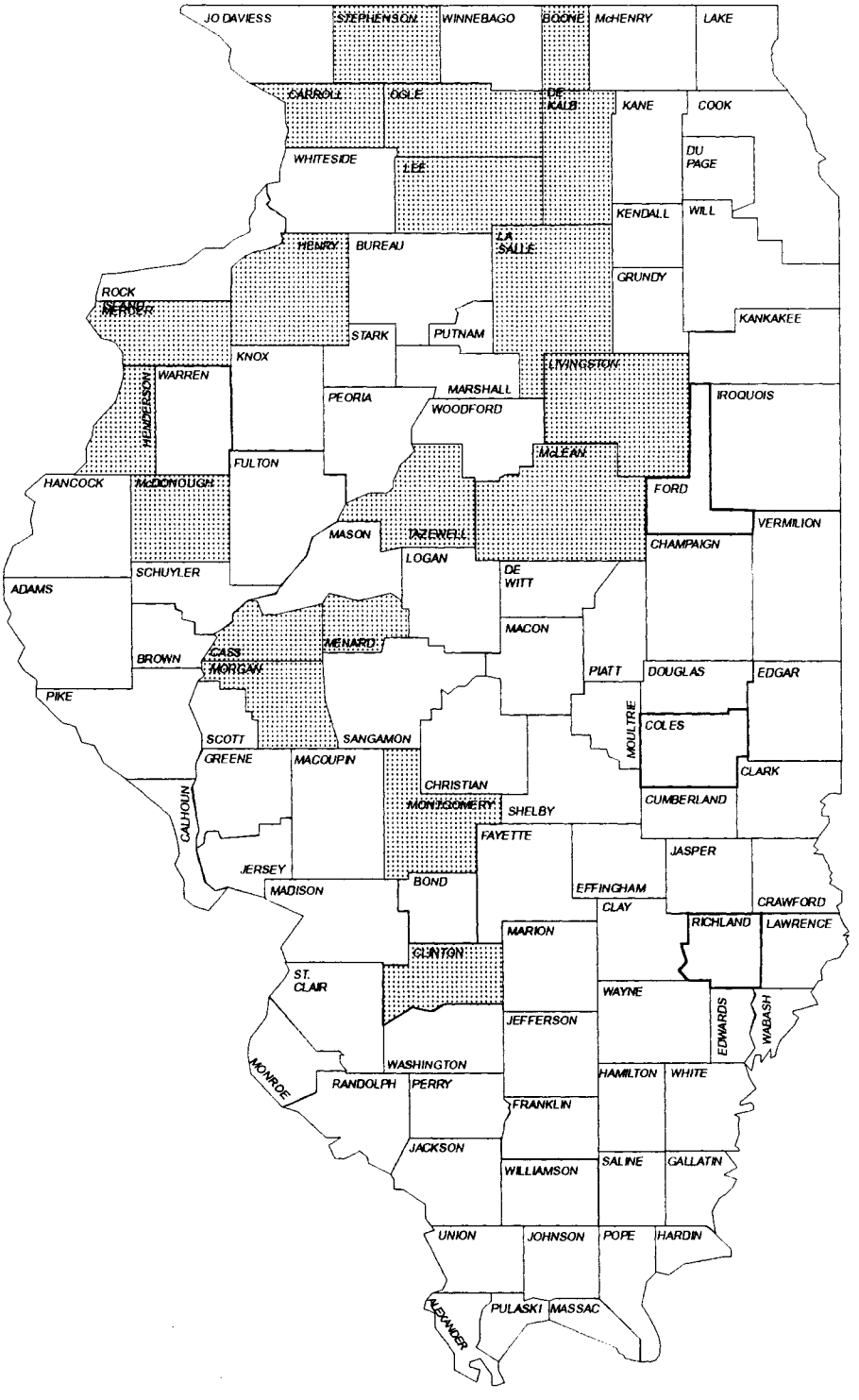


Figure 30. Summary of incidental badger trapping reports from 1989 and 1993 trapper surveys.

= No badgers trapped

= Badgers reported trapped in 2 surveys

= Badger(s) reported trapped in 1 survey

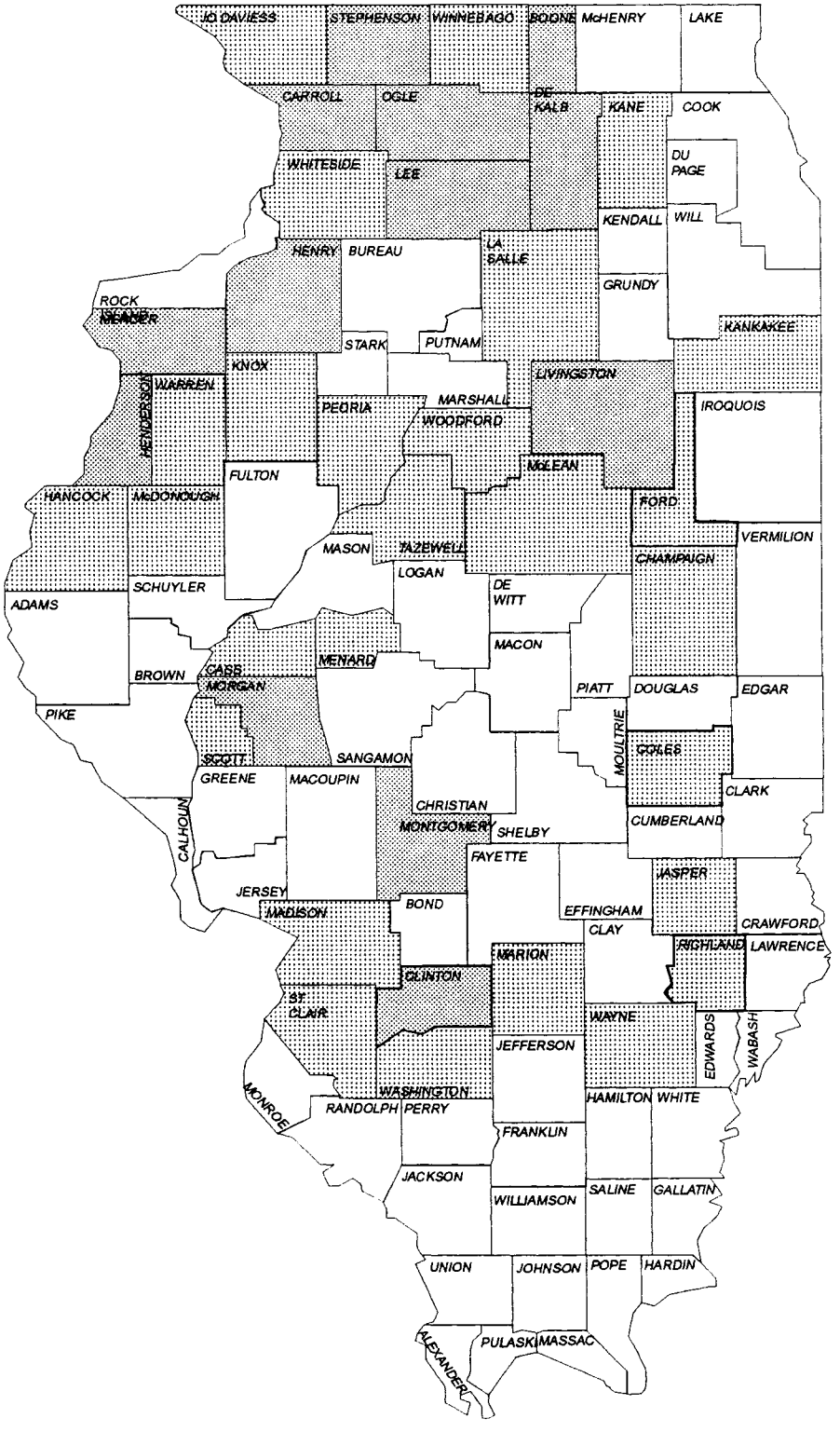


Figure 31. Distribution of badger sightings in 1991 Archery Deer Hunter Survey.

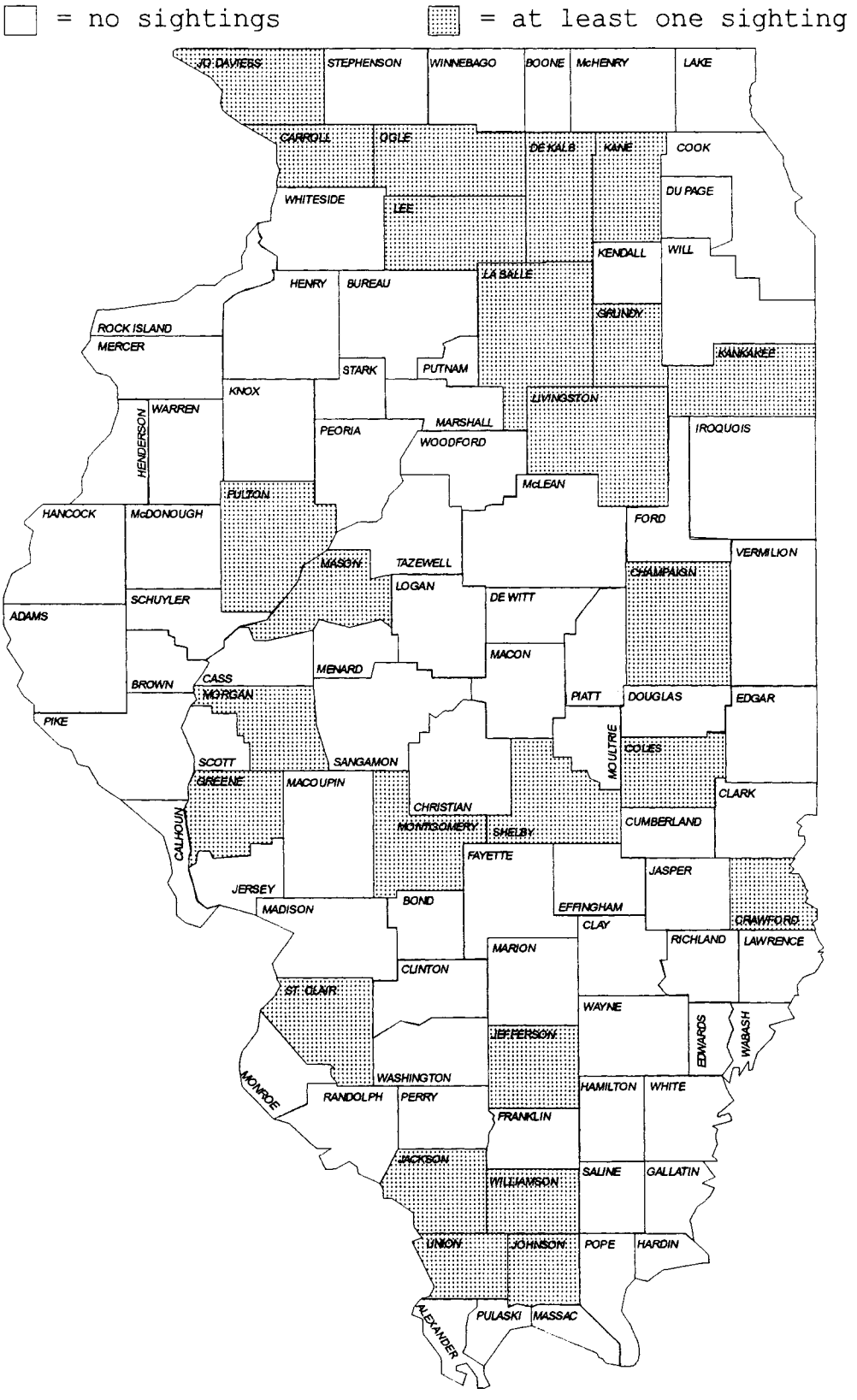


Figure 32. Distribution of badger sightings in 1992 Archery Deer Hunter Survey.

☐ = no sightings ▨ = at least one sighting

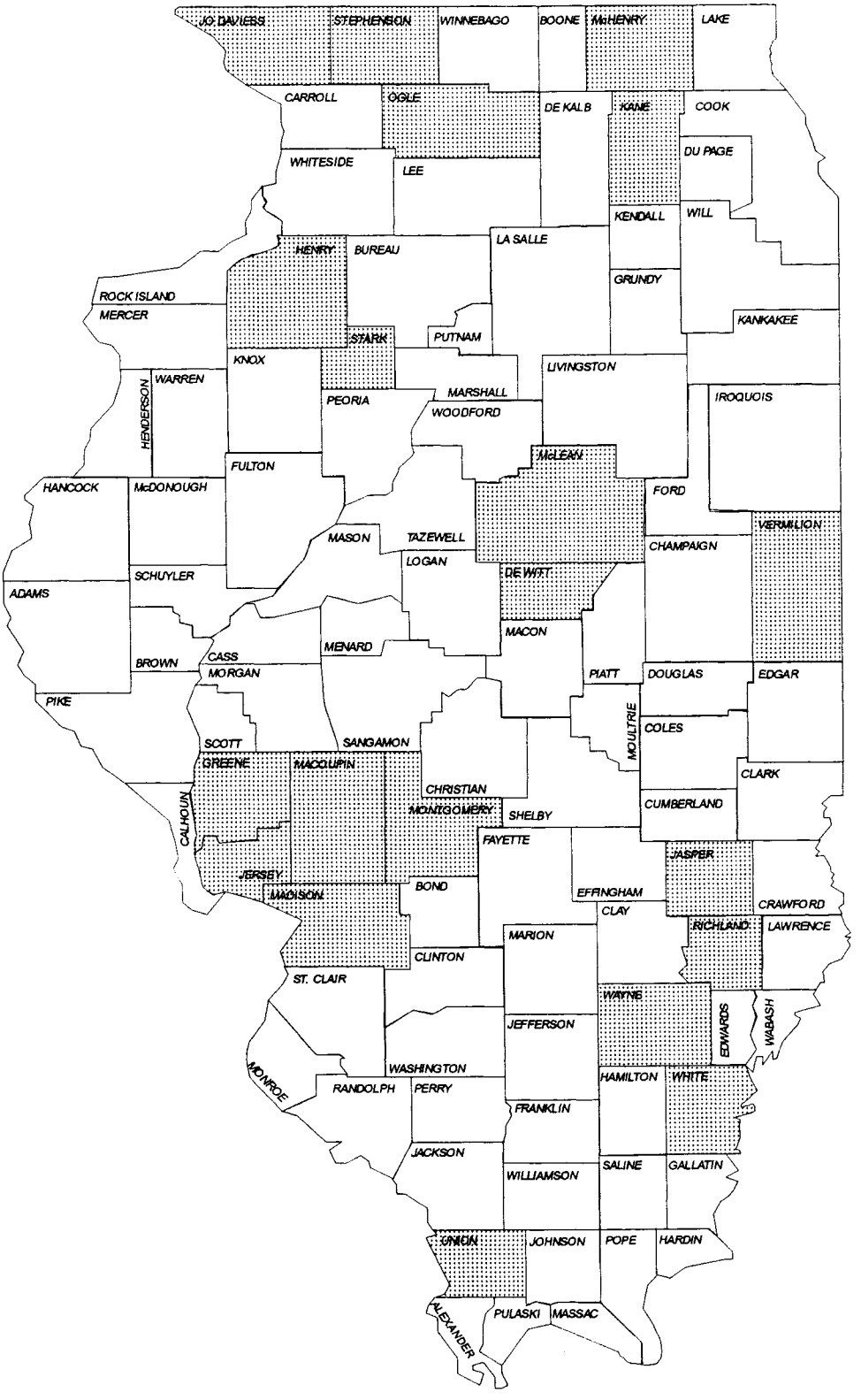


Figure 33. Distribution of badger sightings in 1993 Archery Deer Hunter Survey.

☐ = no sightings ▨ = at least one sighting

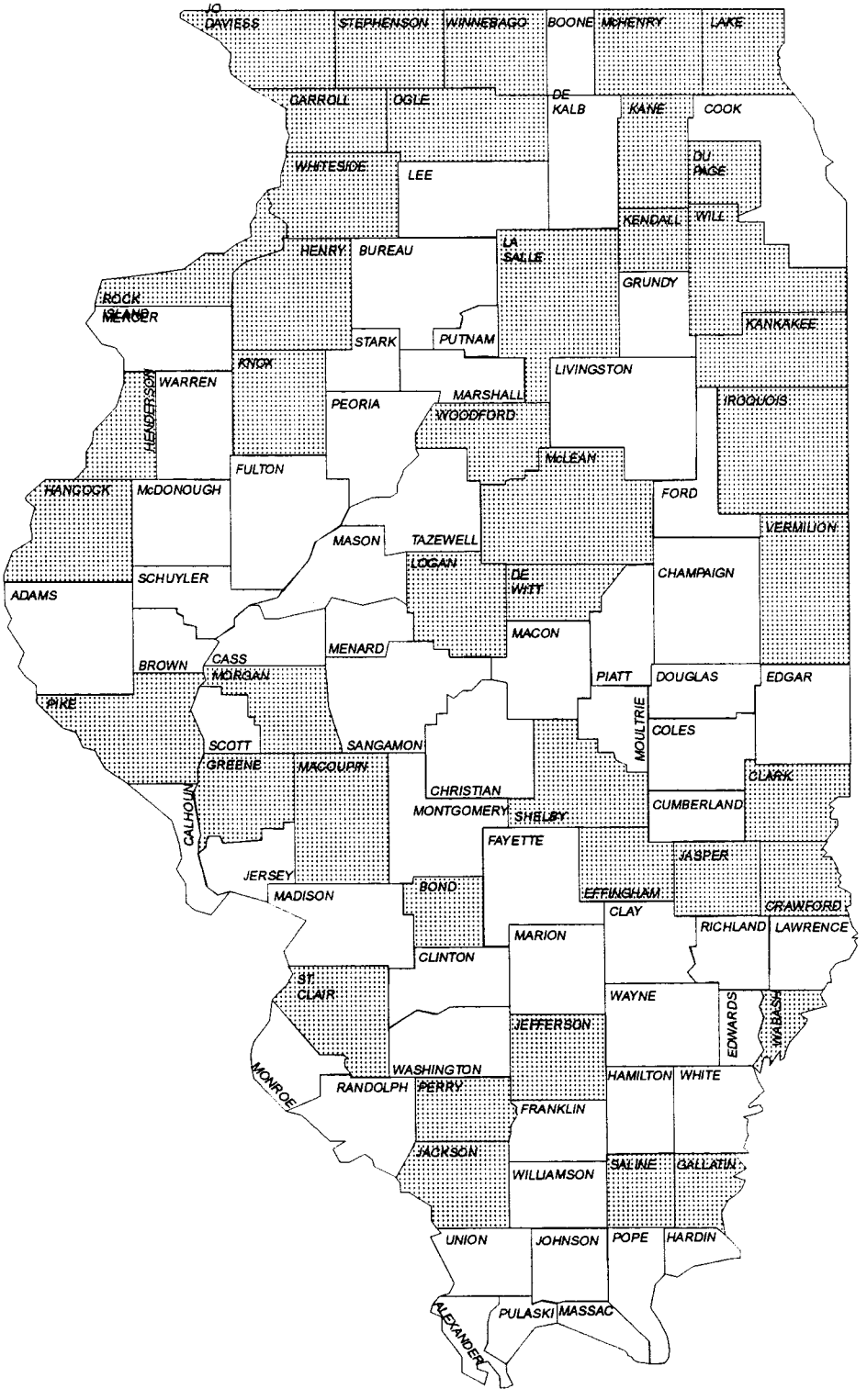


Figure 34. Distribution of badger sightings in 1994 Archery Deer Hunter Survey.

☐ = no sightings ▨ = at least one sighting

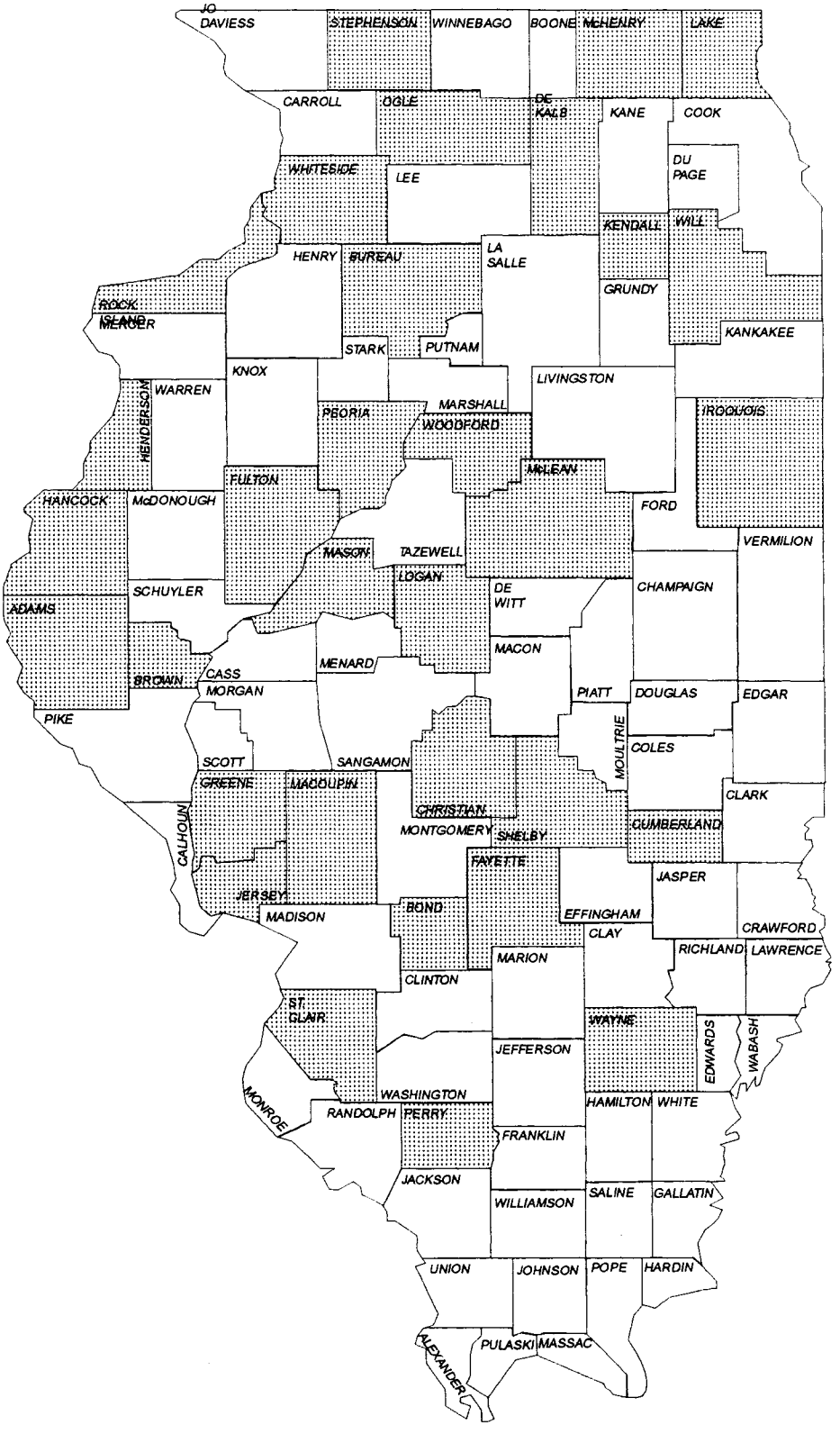


Figure 35. Summary of badger sightings Archery Deer Hunter Survey, 1991-1994.

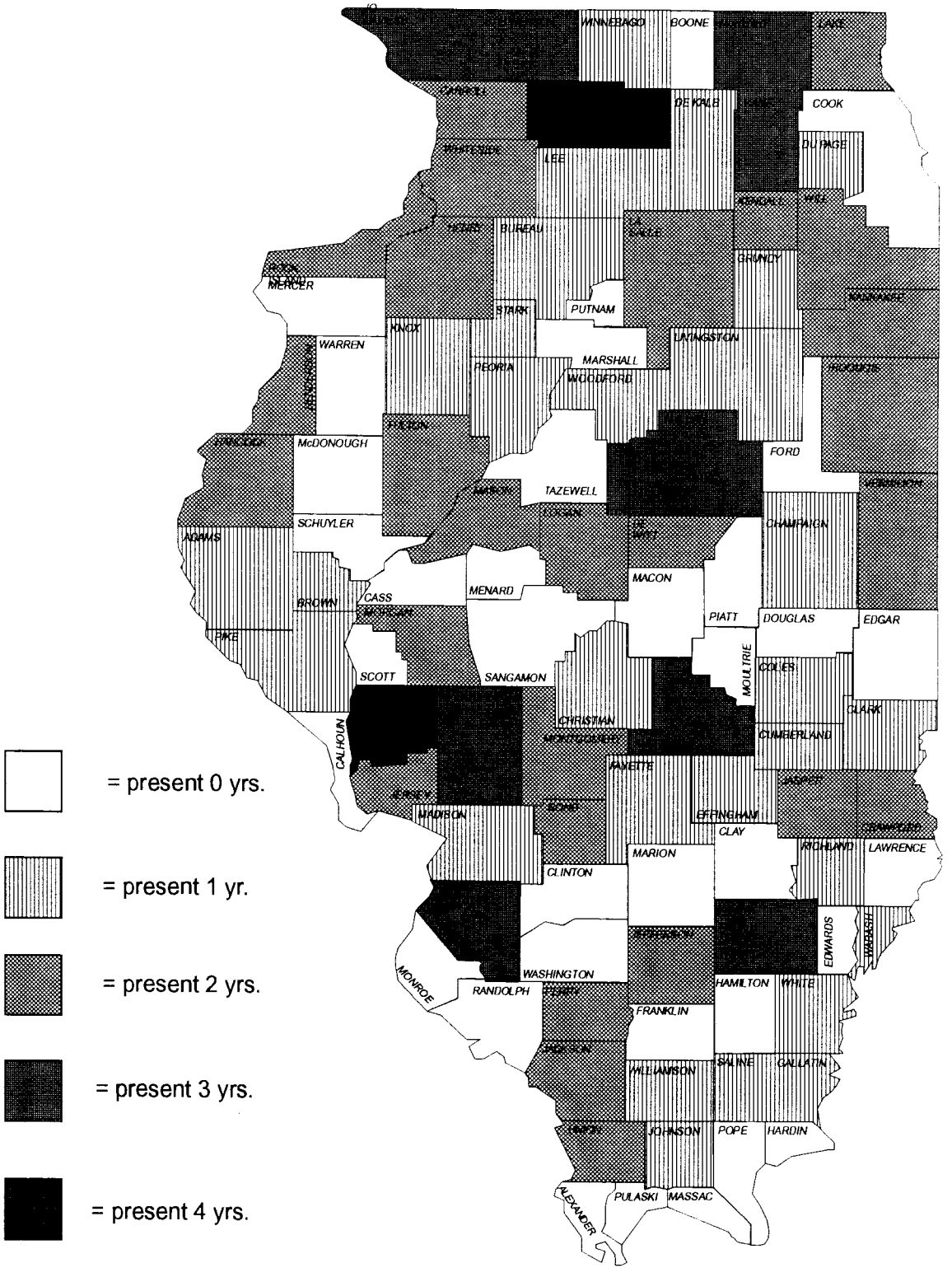


Figure 36. Distribution of counties with high frequency of badger reports in both trapper surveys and the archery deer hunter survey (ADHS).

= Badgers reported trapped in 0 or 1 trapper surveys and sighted in 0 or 1 ADHS years

= Badgers reported trapped in both trapper surveys and sighted in at least 2 ADHS years.

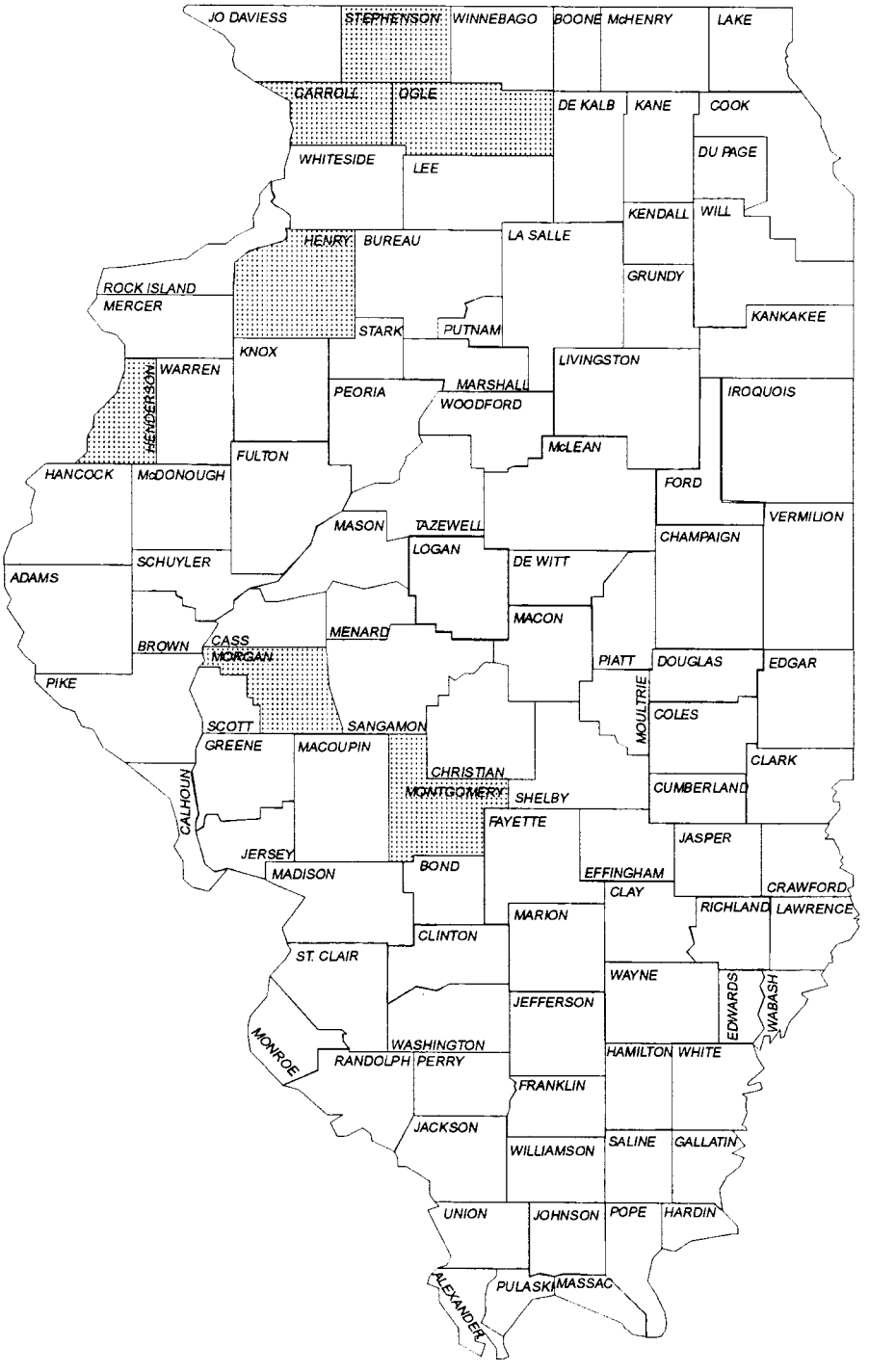


Figure 37. Badger digging site density observed during aerial surveys for red fox project.

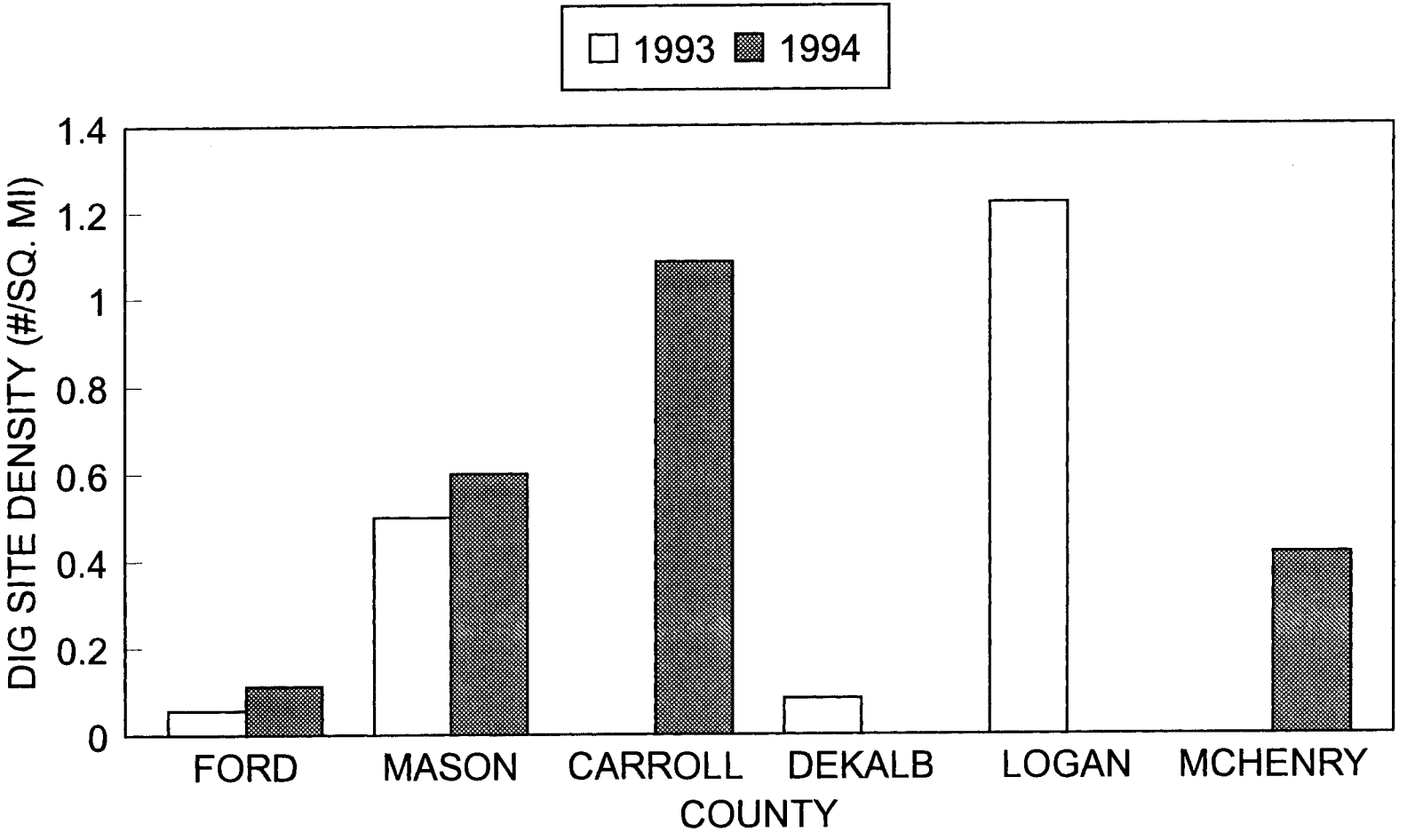


Table 1. Estimates of badger home range overlap. Estimates were calculated only for badger home range pairs which actually exhibited overlap, not for those merely adjacent. N/A signifies an overlap combination that was not monitored adequately to estimate and/or no overlap was detected.

BADGER	SEX	AGE	% OF HOME RANGE OVERLAPPED BY	
			ADULT MALES (NUMBER OF OVERLAPPERS)	ADULT FEMALES (NUMBER OF OVERLAPPERS)
3	F	J	N/A	84.3 (2)
4	F	A	N/A	39.7 (1)
5	F	A	46.9 (2)	25.0 (1)
7	F	A	N/A	N/A
8	F	A	N/A	21.4 (1)
19	M	A	14.1 (1)	32.7 (2)
21	F	A	63.4 (2)	39.1 (2)
22	F	A	61.4 (1)	10.3 (1)
36	M	A	6.2 (1)	N/A
37	M	A	33.2 (1)	70.3 (3)
45	M	A	4.8 (1)	9.8 (1)
49	M	J	37.8 (1)	1.7 (1)
50	F	A	100.0 (1)	N/A
923	F	J	N/A	24.0 (1)

Table 2. Seasonal home ranges for badgers with at least 30 total independent locations.

BADGER	SEX	AGE	SPRING RANGE KM^2 (N)	SUMMER RANGE KM^2 (N)	WINTER RANGE KM^2 (N)
1	M	A	60.69 (13)	57.53 (22)	N/A (4)
3	F	J	N/A (3)	7.19 (19)	4.36 (11)
4	F	A	N/A (5)	8.67 (27)	4.35 (23)
5	F	A	20.16 (63)	49.33 (40)	5.22 (33)
7	F	A	16.88 (107)	23.42 (126)	6.43 (51)
8	F	A	2.78 (43)	19.86 (110)	4.37 (44)
19	M	A	54.44 (51)	16.68 (22)	1.87 (9)
21	F	A	8.43 (47)	26.05 (50)	4.26 (42)
22	F	A	12.63 (63)	9.76 (61)	2.14 (37)
36	M	A	39.66 (19)	8.28 (8)	0.05 (7)
37	M	A	8.74 (12)	15.19 (17)	N/A (3)
41	M	J	N/A (0)	22.47 (25)	1.68 (17)
45	M	A	43.20 (33)	46.68 (16)	9.33 (6)
49	M	J	N/A (0)	7.39 (13)	1.81 (18)
50	F	A	N/A (1)	5.33 (55)	0.97 (16)
923	F	J	N/A (0)	4.79 (39)	0.72 (22)

Table 3. Summary of captured badgers and their fates.

NUMBER	SEX	AGE	CAPTURE DATE	FATE	COMMENTS
23	M	2	06/05/90	Died 8/16/90 above ground, probably due to vehicle collision.	
1	M	3	06/22/90	Died 9/12/90 above ground, probably due to illness, possibly lymphatic cancer.	
3	F	0	07/16/90	Dispersed 7/16/90, date of capture. Signal disappeared 4/12/91; signal probably failed.	Offspring of female #4.
4	F	ADLT	07/16/90	Signal disappeared 5/9/91; fate unknown, but death is more likely than dispersal because female appeared to have established a natal den.	
5	F	7	07/14/90	Signal disappeared on 7/13/93; battery probably failed.	Recaptured and transmitter replaced on 8/11/90.
7	F	2	04/09/91	Signal still operating at project conclusion.	Recaptured and transmitter replaced on 4/3/92.
8	F	3	04/10/91	Signal disappeared on 6/14/94; battery probably failed.	
9	M	0	05/21/91	Died 6/12/91 in burrow, probably because mother died.	Offspring of female #10.

Table 3. Summary of captured badgers and their fates.

NUMBER	SEX	AGE	CAPTURE DATE	FATE	COMMENTS
10	F	2	05/21/91	Died 6/12/91 in burrow, possibly died when field with burrow was cultivated.	
11	M	0	05/22/91	Died 6/12/91 in burrow, probably because mother died.	Offspring of female #10.
12	F	0	05/29/91	Signal disappeared 7/9/91; probably dispersed.	Offspring of female #5.
13	M	0	06/05/91	Signal disappeared 7/24/91; probably dispersed.	Offspring of female #8.
14	F	0	06/06/91	Died in burrow 6/19/91; possibly due to infection from transmitter.	Offspring of female #8.
15	M	2	06/06/91	Died 8/8/91 in burrow; follows possible encounter with second male.	
17	M	2	06/14/91	Badger died by 11/26/91; transmitter recovered near latent burrow; badger probably in burrow.	
18	M	ADLT	07/11/91	Died 10/25/91 in burrow; unknown cause.	
19	M	1	03/20/92	Signal disappeared on 5/23/94; battery probably failed.	
20	M	4	04/01/92	Signal disappeared on 8/10/92; unknown cause.	
21	F	7	04/03/92	Signal still operating at project conclusion.	

Table 3. Summary of captured badgers and their fates.

NUMBER	SEX	AGE	CAPTURE DATE	FATE	COMMENTS
22	F	4	04/09/92	Died 5/31/94 in burrow, probably died when roadside with burrow was mown.	Unmarked offspring was with female, also died.
923	F	0	05/18/92	Dispersed 7/8/92. Signal disappeared on 1/15/93; battery may have failed or badger may have dispersed out of area.	Offspring of female #21.
024	M	0	05/18/92	Died 6/16/92 above ground; unknown cause, possibly predated.	Offspring of female #21.
026	F	0	05/29/92	Died 7/14/92 above ground; probably killed by dog(s).	Offspring of female #7.
027	F	0	06/03/92	Signal disappeared 7/29/92, probably dispersed.	Offspring of female #8.
028	M	0	06/03/92	Died 6/12/92 in burrow; unknown cause.	Offspring of female #8.
029	F	0	06/16/92	Died 7/6/92 above ground; killed by coyotes.	Offspring of female #22.
030	F	0	06/16/92	Died 6/23/92 above ground; killed by coyotes.	Offspring of female #22.
031	M	0	06/17/92	Died 6/23/92 above ground; killed by coyotes.	Offspring of female #22.
039	M	5	09/30/92	Died 9/30/92 during blood collection at veterinarian's office.	
036	M	9	04/11/93	Died 4/15/94 above ground; died of illness, possibly related to advanced age.	

Table 3. Summary of captured badgers and their fates.

NUMBER	SEX	AGE	CAPTURE DATE	FATE	COMMENTS
037	M	2	04/23/93	Died 12/9/93 in burrow; died from injuries when field with burrow was plowed.	
040	F	0	05/25/93	Died 6/5/93 above ground; killed by predator.	Offspring of female #8.
041	M	0	05/26/93	Dispersed 7/20/93. Signal disappeared 3/22/94; battery probably failed.	Offspring of female #8
042	F	0	06/08/93	Dispersed 7/27/93. Died 10/7/93 in burrow; probably died when field with burrow was harvested.	Offspring of female #7.
043	M	0	06/08/93	Died 6/16/93, above ground; probably due to infection from transmitter surgery.	Offspring of female #7.
045	M	4	12/19/93	Signal disappeared 9/26/94; unknown cause.	
046	M	0	06/01/94	Dispersed 7/18/94. Died 8/10/94 above ground; possible starvation.	Offspring of female #50.
047	M	0	06/01/94	Probably dispersed 7/14/94 (mother is unmarked). Signal disappeared 9/7/94; unknown cause.	Sibling of #49.
048	F	0	06/06/94	Dispersed 7/28/94. Died 10/11/94 above ground, probably killed by coyote or dog.	Offspring of female #50.
049	M	0	06/16/94	Probably dispersed 7/14/94 (mother is unmarked). Signal disappeared 1/23/95; unknown cause.	Sibling of #47.

Table 3. Summary of captured badgers and their fates.

NUMBER	SEX	AGE	CAPTURE DATE	FATE	COMMENTS
050	F	4	07/01/94	Signal still operating at project conclusion.	
051	F	0	07/09/94	Dispersed 7/31/94. Died above ground 8/8/94; killed by vehicle collision.	Offspring of female #21.

Table 4. Number of locations and daily movements for badgers used in home range and movement analyses. Data for juveniles are post-dispersal only.

BADGER	SEX	AGE	TOTAL NUMBER OF LOCATIONS	NUMBER OF INDEPENDENT LOCATIONS	NUMBER OF MOVEMENTS BETWEEN CONSECUTIVE DAYS
1	M	A	53	36	12
3	F	J	50	32	7
4	F	A	75	55	14
5	F	A	256	135	37
7	F	A	527	282	88
8	F	A	486	193	79
10	F	A	7	3	0
15	M	A	17	10	5
17	M	A	3	3	0
18	M	A	17	14	2
19	M	A	186	80	18
20	M	A	10	6	3
21	F	A	412	137	37
22	F	A	359	159	42
23	M	A	21	20	5
36	M	A	84	32	5
37	M	A	45	32	12
41	M	J	56	42	19
42	F	J	42	25	12
45	M	A	106	54	21
46	M	J	8	6	2
47	M	J	27	18	11
48	F	J	32	25	13

Table 4. Number of locations and daily movements for badgers used in home range and movement analyses. Data for juveniles are post-dispersal only.

BADGER	SEX	AGE	TOTAL NUMBER OF LOCATIONS	NUMBER OF INDEPENDENT LOCATIONS	NUMBER OF MOVEMENTS BETWEEN CONSECUTIVE DAYS
49	M	J	57	31	15
50	F	A	111	72	35
51	F	J	4	3	1
923	F	J	95	61	33

Table 5. Badger home range results. Estimates are 95% Minimum Convex Polygons (MCP).

BADGER	SEX	AGE	95% MCP(KM^2)	NUMBER OF LOCATIONS USED TO ESTIMATE HOME RANGE
1	M	A	69.99	36
3	F	J	9.68	32
4	F	A	10.47	55
5	F	A	36.63	135
7	F	A	27.51	282
8	F	A	19.63	193
15	M	A	1.60	10
18	M	A	18.07	14
19	M	A	56.17	80
20	M	A	4.76	6
21	F	A	26.18	137
22	F	A	11.24	159
23	M	A	19.13	20
36	M	A	39.82	32
37	M	A	23.39	32
41	M	J	30.00	42
42	F	J	2.34	25
45	M	A	57.06	54
46	M	J	0.55	6
47	M	J	4.80	18
48	F	J	4.48	25
49	M	J	8.10	31
50	F	A	5.48	72
923	F	J	4.98	61

Table 6. Estimates of badger home range overlap for age and sex classes.

SEX/AGE CLASS	MEAN % OF HOME RANGE OVERLAPPED BY ADULT MALES	MEAN % OF HOME RANGE OVERLAPPED BY ADULT FEMALES
ADULT FEMALES (N=4)	67.93	27.10
ADULT MALES (N=4)	14.58	37.60
JUVENILES (N=3)	37.80	36.67

Table 7. Estimates of seasonal badger home range overlap. Percent overlap was calculated for each seasonal home range (focal season) relative to any seasonal home ranges that were larger than it (target seasons). Home range estimates used in overlap analysis are 95% MCP.

BADGER	SEX	AGE	FOCAL SEASON	PERCENT OF FOCAL SEASON HOME RANGE OVERLAPPED BY TARGET SEASON HOME RANGE (TARGET SEASON, %)
1	M	A	SUMMER	SPRING, 86.2
4	F	A	SPRING	SUMMER, 100.0
4	F	A	SPRING	WINTER, 100.0
4	F	A	WINTER	SUMMER, 94.0
5	F	A	SPRING	SUMMER, 92.6
5	F	A	WINTER	SPRING, 100.0
5	F	A	WINTER	SUMMER, 100.0
7	F	A	SPRING	SUMMER, 95.2
7	F	A	WINTER	SPRING, 79.9
7	F	A	WINTER	SUMMER, 80.6
8	F	A	SPRING	SUMMER, 100.0
8	F	A	SPRING	WINTER, 78.7
8	F	A	WINTER	SUMMER, 100.0
19	M	A	SUMMER	SPRING, 100.0
19	M	A	WINTER	SPRING, 68.1
19	M	A	WINTER	SUMMER, 68.1
21	F	A	SPRING	SUMMER, 98.5
21	F	A	WINTER	SPRING, 67.8
21	F	A	WINTER	SUMMER, 99.9
22	F	A	SUMMER	SPRING, 72.2
22	F	A	WINTER	SPRING, 100.0
22	F	A	WINTER	SUMMER, 94.9

Table 7. Estimates of seasonal badger home range overlap. Percent overlap was calculated for each seasonal home range (focal season) relative to any seasonal home ranges that were larger than it (target seasons). Home range estimates used in overlap analysis are 95% MCP.

BADGER	SEX	AGE	FOCAL SEASON	PERCENT OF FOCAL SEASON HOME RANGE OVERLAPPED BY TARGET SEASON HOME RANGE (TARGET SEASON, %)
36	M	A	SUMMER	SPRING, 45.7
36	M	A	WINTER	SPRING, 0.0
36	M	A	WINTER	SUMMER, 0.0
37	M	A	SPRING	SUMMER, 53.7
45	M	A	SPRING	SUMMER, 81.6
45	M	A	WINTER	SPRING, 77.8
45	M	A	WINTER	SUMMER, 64.9
50	F	A	WINTER	SUMMER, 94.5
49	M	J	WINTER	SUMMER, 81.0
3	F	J	WINTER	SUMMER, 79.1

Table 8. Summary of yearly badger home range estimates. Estimates are 95% Minimum Convex Polygons and are reported in km^2 (N=number of locations).

BADGER	SEX	AGE	1990	1991	1992	1993	1994
1	M	A	58.61 (27)	5.57 (11)	-	-	-
4	F	A	10.15 (42)	2.16 (15)	-	-	-
5	F	A	8.10 (13)	12.19 (34)	34.37 (68)	7.70 (22)	-
7	F	A	-	16.88 (34)	18.85 (77)	23.21 (78)	12.20 (91)
8	F	A	-	13.54 (46)	7.55 (68)	9.40 (65)	1.33 (14)
19	M	A	-	-	16.10 (11)	39.79 (47)	5.92 (23)
21	F	A	-	-	23.05 (43)	10.67 (56)	8.62 (35)
22	F	A	-	-	10.54 (54)	9.63 (95)	1.76 (10)
36	M	A	-	-	-	22.22 (21)	7.69 (11)

Table 9. Estimates of yearly badger home range overlap. Percent overlap was calculated for each annual home range (focal year) relative to any annual home ranges that were larger than it (target years). Home range estimates used in overlap analysis are 95% MCP.

BADGER	SEX	AGE	FOCAL YEAR	PERCENT OF FOCAL YEAR HOME RANGE OVERLAPPED BY TARGET YEAR HOME RANGE (TARGET YEAR, %)
1	M	A	1991	1990, 75.2
4	F	A	1991	1990, 95.8
5	F	A	1990	1991, 78.1
5	F	A	1990	1992, 100.0
5	F	A	1991	1992, 98.1
5	F	A	1993	1990, 51.2
5	F	A	1993	1991, 62.3
5	F	A	1993	1992, 100.0
7	F	A	1991	1992, 65.0
7	F	A	1991	1993, 74.0
7	F	A	1992	1993, 91.9
7	F	A	1994	1991, 40.8
7	F	A	1994	1992, 95.2
7	F	A	1994	1993, 99.6
8	F	A	1992	1991, 79.7
8	F	A	1992	1993, 78.4
8	F	A	1993	1991, 93.7
8	F	A	1994	1991, 100.0
8	F	A	1994	1992, 100.0
8	F	A	1994	1993, 100.0
19	M	A	1992	1993, 91.0
19	M	A	1994	1992, 3.8
19	M	A	1994	1993, 37.0

Table 9. Estimates of yearly badger home range overlap. Percent overlap was calculated for each annual home range (focal year) relative to any annual home ranges that were larger than it (target years). Home range estimates used in overlap analysis are 95% MCP.

BADGER	SEX	AGE	FOCAL YEAR	PERCENT OF FOCAL YEAR HOME RANGE OVERLAPPED BY TARGET YEAR HOME RANGE (TARGET YEAR, %)
21	F	A	1993	1992, 99.5
21	F	A	1994	1992, 76.7
21	F	A	1994	1993, 35.2
22	F	A	1993	1992, 94.7
22	F	A	1994	1992, 98.2
22	F	A	1994	1993, 85.3
36	M	A	1994	1993, 50.2

Table 10. Summary of badger carcasses collected in Illinois.

AGE/SEX CLASS		#	PERIOD COLLECTED				CAUSE OF DEATH		
AGE	SEX		SPRING	SUMMER	WINTER	UNKNOWN	ROADKILL	TRAP	OTHER
ADULT	F	40	14	13	6	7	37	3	0
ADULT	M	45	12	16	9	8	38	1	6
ADULT	U	1	0	0	1	0	0	1	0
JUVENILE	F	14	3	5	3	3	11	1	2
JUVENILE	M	19	6	8	0	5	17	0	2
UNKNOWN	F	12	3	2	5	2	8	2	2
UNKNOWN	M	6	0	0	4	2	5	1	0
TOTAL #	-	137	38	44	28	27	116	9	12
TOTAL PROPORTION	-	-	0.28	0.32	0.20	0.20	0.85	0.07	0.09

Table 11. Reproductive status of adult female carcasses collected in Illinois.

AGE	REPRODUCTIVE STATUS		
	HAD BRED	HAD NOT BRED	UNKNOWN
1	2	1	3
2	1	5	3
3	5	2	2
4	1	0	4
5	1	0	1
6	2	0	1
9	1	0	0
11	1	0	0
UNKNOWN	6	5	13
TOTAL	20	13	27

Table 12. Potential badger prey density and number of species by cover type.

COVER TYPE	PREY DENSITY (#/HA)	PREY SPECIES TRAPPED (#)	SECONDARY COVER CATEGORY
Alfalfa	21.18	*Microtus ochrogaster, Mus musculus, Peromyscus maniculatus, Reithrodontomys megalotis* (4)	Undisturbed
CRP	21.80	*Microtus ochrogaster, Peromyscus leucopus, Peromyscus maniculatus, Reithrodontomys megalotis* (4)	Undisturbed
Hedgerow	24.07	*Blarina brevicauda, Microtus ochrogaster, Peromyscus leucopus, Peromyscus maniculatus, Zapus hudsonius* (5)	Undisturbed
Roadside	17.73	*Blarina brevicauda, Microtus ochrogaster, Mus musculus, Peromyscus leucopus, Peromyscus maniculatus, Reithrodontomys megalotis, Spermophilus tridecemlineatus* (7)	Undisturbed
Row crops (corn, soybeans, wheat, rye)	13.58	*Mus musculus, Peromyscus leucopus, Peromyscus maniculatus* (3)	Disturbed

Table 13. For adult badgers, number and percent of burrows in disturbed and undisturbed cover categories.

	DISTURBED COVERS		UNDISTURBED COVERS	
BADGER	NUMBER OF BURROWS	PERCENT OF BURROWS	NUMBER OF BURROWS	PERCENT OF BURROWS
1	3	13	20	87
4	2	6	31	94
5	25	30	58	70
7	47	29	113	71
8	20	15	116	85
19	16	29	39	71
21	31	42	42	58
22	35	51	34	49
36	3	14	19	86
37	12	48	13	52
45	14	38	23	62
50	25	71	10	29

Table 14. Burrow cover use summary for 10 adult badgers using individual home range cover types to estimate number of burrows expected in each cover type, according to cover availability. Disturbed cover types = "D" and undisturbed cover types = "U".

BADGER	# BURROWS	% OF RANGE		# BURROWS IN "D" COVER		# BURROWS IN "U" COVER	
		"D" COVER	"U" COVER	EXPECTED	OBSERVED	EXPECTED	OBSERVED
4	33	72	28	24	2	9	31
5	68	82	18	68	25	15	58
7	171	87	13	149	50	22	121
8	141	51	49	72	20	69	121
19	60	70	30	42	17	18	43
21	76	82	18	62	33	14	43
22	70	90	10	63	35	7	35
36	22	55	45	12	3	10	19
37	25	84	16	21	12	4	13
45	37	94	6	35	14	2	23

Table 15. For adult badgers, distance of burrows and random locations to nearest linear cover (corridor).

BADGER	MEAN DISTANCE (M) OF BURROWS TO NEAREST CORRIDOR	MEAN DISTANCE (M) OF RANDOM LOCATIONS (WITHIN HOME RANGE) TO NEAREST CORRIDOR
4	408.06	439.75
5	356.78	490.75
7	311.51	498.23
8	458.83	395.45
19	301.12	593.05
21	333.54	413.36
22	278.78	300.82
36	253.88	496.86
37	291.66	384.71
45	276.16	424.76
50	312.84	258.13

Table 16. Results of stomach content analysis for 19 badgers.

PREY CATEGORY	PERCENT OCCURRENCE
MAMMALS	0.89
Geomys bursarius	0.06
Marmota monax	0.18
Microtus sp.	0.29
Spermophilus sp.	0.18
Zapus hudsonius	0.06
Small rodents (*Peromyscus sp.*, etc.)	0.59
HERPS (Snakes and toads)	0.21
BIRDS (Passerine)	0.05
INSECTS (Beetles)	0.05
VEGETABLE MATTER (Mulberries)	0.11
SAMPLE INCLUDES AT LEAST 1 SPECIES MOST LIKELY FOUND IN UNDISTURBED COVER TYPES (Everything except "small rodents", and insects).	0.74
SAMPLE INCLUDES **ONLY** SPECIES MOST LIKELY FOUND IN DISTURBED COVER TYPES ("Small mammals" category and insects)	0.26

Table 17. Badger density estimation by extrapolation for Mason County, Illinois.

CATEGORY	A MEAN 95% MCP HOME RANGE (KM^2)	B MEAN % INTRASEXUAL HOME RANGE OVERLAP	C MEAN % OF HOME RANGE THAT IS EXCLUSIVE (100-B)	D MEAN HOME RANGE AREA THAT IS EXCLUSIVE (KM^2) (A*C)	E ESTIMATED BADGER DENSITY (#/KM^2) (1/D)
ADULT FEMALES	13.05	27.1	72.9	9.51	0.11
ADULT MALES	44.44	37.6	62.4	27.52	0.04
TOTAL ADULTS	-	-	-	-	0.14

APPENDIX A.

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